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ABSTRACT

In the first section of this book, seven papers are presented which were given at the working conference on Computer Applications in Dental Education held in San Francisco in October 1969. Three of the papers are statements by educators (Lawrence M. Stolurow, Ralph E. Grubb, and John A. Starkweather) who have been active for several years in the area of computer-assisted instruction (CAI) outside the context of dental education. The remaining papers deal with the use of computers in four areas of dental education: admissions, instructions, dental school operations, and evaluation of clinical course work. In the second section, along with brief reports on the four conference discussion groups, summaries are presented of computer projects in progress at the dental schools represented at the conference. The project summaries are divided into four areas of application: Admissions and academic evaluation, CAI, dental school operations and educational administration, and student evaluation in clinical course work. The types of projects summarized include computer assistance in the admission process, automated scanning analysis of dental X-rays, development of an automated dental training simulator, and computerized student evaluation systems. A directory of conference participants includes a brief indication of the computer system, areas of application, and project status of each conference. (Author/JY)

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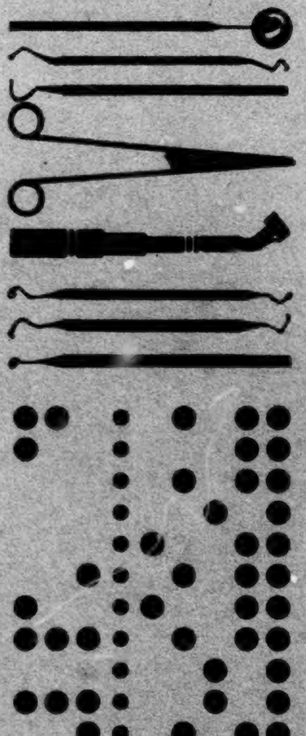

COMPUTER APPLICATIONS IN DENTAL EDUCATION

a conference report

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service National Institutes of Health

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IN DENTAL
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COMPUTER APPLICATIONS IN DENTAL EDUCATION

a conference report

Division of Dental Health
Dental Health Center
Professional Education Branch

DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
Public Health Service National Institutes of Health
Bureau of Health Manpower Education

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PREFACE

In recent years our nation's dental schools have shown a growing interest in using computers to solve their educational problems. In order to promote cooperation and communication among dental schools in their efforts, a working conference on "Computer Applications in Dental Education" was held at San Francisco, California during October 29-31, 1969. Sponsored by the Professional Education Branch (of the Division of Dental Health, Bureau of Health Manpower Education, National Institutes of Health), the meeting was attended by some eighty participants representing thirty-five American and Canadian dental schools, by staff members of the Division of Dental Health, and by observers from the National Library of Medicine and the Division of Physician Manpower, BHME, NIH.

In addition to bringing together dental educators to exchange information and discuss present problems, the conference was intended as a means of providing guidance for dental schools which in the future may come to consider the use of computers. Consequently, this report has been published to provide a readily available source of information as more dental schools begin to introduce computers into some phase of the educational process.

Part 1 consists of seven papers based on formal presentations made by the invited speakers. Part 2 contains summaries of computer projects in progress at the dental schools represented at the conference, organized by four areas of application: (1) admissions and academic evaluation, (2) computer-assisted instruction, (3) dental school operations and educational administration, and (4) student evaluation in clinical coursework. The appendix lists the conference participants with their addresses and telephone numbers as of May 1970, with each entry followed by a brief indication of the computer system the individual is using, his area of application, and the status of his project.

The publications from three recent meetings contain information of interest to the dental educator who is beginning to explore the uses of computers. In February 1968, a Conference on Computer-Assisted Instruction in Medical Education was held at the Harvard University Medical School. The proceeds of the meeting, entitled *Computer Assisted Instruction in the Health Professions* (Stolurow, Peterson & Cunningham, eds., 1970) can be obtained from ENTELEK, INC., Newburyport, Massachusetts 01950. In April 1968, the Conference on the Use of Computers in Medical Education was held at the University of Oklahoma, School of Medicine. The *Proceedings* of that conference are available from the Office of Information, Division of Physician and Health Professions Education, BHME, NIH, 9000 Rockville Pike, Bethesda, Maryland 20014. In June 1969, a conference on Comprehensive Care in Clinical Dental Education was sponsored by the University of North Carolian and copies of the *Proceedings* are available from Dr. Clifton E. Crandell, University of North Carolina, School of Dentistry, Chapel Hill, North Carolina 27515. In addition, the *Index to Computer Assisted Instruction* (Lekan, ed., 1970) available through the Sterling Institute, 3750 Prudential Tower, Boston, Massachusetts 02199, summarizes some eighty computer-assisted instruction programs written for health professions education.

I would like to thank the authors of the papers and project summaries for reviewing their material for publication and to acknowledge the labor of the editors who transformed the manuscripts into a book: Luigi F. Lucaccini, Martin L. MacIntyre and Jack Handley.

Dale W. Podshadley, D.D.S.
Conference Chairman

DALE W. PODSHADLEY is Chief, Professional Education Branch, Division of Dental Health, Bureau of Health Professions Education and Manpower Training, National Institutes of Health, San Francisco, California. He received his D.D.S. from St. Louis University and his M.P.H. from the University of Michigan. He has directed an ongoing program of applied research in dental education for the Division of Dental Health since 1961. Present program areas include the recruitment, selection, and development of dental students and teachers; the application of modern instructional technology to dental education; the development of continuing dental education systems; human factors in the design of dental instructional facilities; and the administration of dental educational systems. In addition to having published numerous papers in the area of dental education, he is co-author of the programmed text, *Introduction to Dental Public Health*. He serves on the faculties of the University of California School of Dentistry and the University of Pacific School of Dentistry, and is a Diplomate of the American Board of Dental Public Health.

INTRODUCTION

Dale W. Podshadley
Professional Education Branch, Division of
Dental Health

One of the most significant events of recent years was the public acknowledgment by the health professions that health is a right of the people. When we in the health fields acknowledged this, we immediately accepted the responsiblity to see that care is available to all. Given the shortage of health manpower, this responsibility constitutes a tremendous challenge. It is obvious that the health professions must develop new systems for delivering comprehensive health services. The resources of personnel, administrative mechanisms, and facilities must be organized in new subsystems to radically increase their efficiency, effectiveness and economy before the public can receive the care it needs.

Let us look briefly at some of the subsystems which comprise dental education; in particular, students, faculty, administration, facilities, and practicing dentists. In order to increase manpower, new schools have been created and existing ones have expanded their enrollments. Between 1965 and 1975 there will be more than a one-third increase in the number of graduates, finally reaching 4,300 annually. Unfortunately, this dramatic and necessary increase in the number of students has compounded the problem of the shortage of teachers. As Dr. Diefenbach emphasized in his remarks:

> Our dental schools find themselves hard-pressed to retain qualified teaching staffs. Those people who do accept the challenge of teaching find it increasingly difficult to keep up to date in dental science. Increasing class sizes, the need for continuous curriculum improvement, and the need to individualize instruction are some of the factors which work against teachers operating at optimal effectiveness and efficiency.*

The expansion of the dental curriculum deserves special recognition. Because of social change and increased social awareness, many new content areas are being added which previously were not considered as being essential in the practice of dentistry. Elements of psychology, sociology, anthropology, economics, and political science are but a few of the disciplines now being included in dental education. At the same time the knowledge explosion has greatly added to the content of traditional courses and will continue to do so.

> These factors make it imperative that new and improved educational and administrative methods be sought out and applied as rapidly as possible. We must ensure the production of graduates in the quantity and of the quality required to maintain and improve the oral health of the American people. The time is now for dental educators to study carefully the potential of computer technology and to begin to apply it effectively to their problems on a large scale basis.**

Let us look now at problem areas where computer technology can provide solutions. In the manpower area a great deal has been written about the expanded use of auxiliaries, including the development of entirely new disciplines, as a partial answer to the manpower shortage. Very little, however, has been written about the problems of recruiting and selecting individuals in a manner to ensure career satisfaction. There is, probably, little economy in expanding the duties of auxiliaries if attrition continues at the present rate. Almost the same problem exists in regard to training dentists. In dental practice of the future, it is likely that the dentist will be a specialist in diagnosis and treatment planning, community leadership, and administration. This new type of practice will require a person different from the one who is now choosing a career in dentistry.

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*Welcoming address of Dr. Viron L. Diefenbach, former director of the Division of Dental Health, Bureau of Health Professions Education and Manpower Training, National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare.

**Diefenbach, *op. cit.*

Data banks are one answer to both of these problems of selecting people for dental careers. Computers are the only answer to the management of data banks. With cumulative information, it should be possible to continually update the selection criteria to meet the needs of society. A great deal of research and development effort is needed, particularly in identifying the factors which determine "success" in private practice.

Assuming that students can be selected on the bases of career success and happiness, it is important, next, to ensure that each student be allowed to realize his potential. I doubt very much if the students of the future are going to settle for less. They are going to expect freedom and the right to exercise their individual initiative. Probably of greatest need is curricular flexibility to meet the interest and capabilities of individual students. Although some form of core curriculum might be required, beyond that point students must be given maximum freedom if they are to develop fully.

In recent years there has been a great deal of interest in the processes of teaching and learning. For the problems of the teacher shortage and of reaching a large number of students, educational television was somewhat of an answer. To provide information when a student wants it, dial and random access capabilities have been developed. To enrich learning experiences by involving more than one sense mode, single- and multiple-concept films and filmstrips are now available.

To personalize and individualize instruction, utilizing the learning principles of immeidate reinforcement and active participation, one answer is computer-assisted instruction (CAI). Only CAI would appear at this point to answer the problems arising from individual goals. I doubt if adequate curriculum flexibility can be achieved without it. Developing people to their potential implies continuing their education until they reach their peak. Practically speaking, this suggests that a girl who originally enrolls in a dental assisting curriculum should be able to go on to become a dentist or pediatrician or nuclear physicist, if she desires, with minimum repetition of coursework and loss of time.

An automated system with almost unlimited storage, retrieval and evaluation capabilities is essential. A retrieval system under computer control merits some elaboration. A library of prerecorded instructional materials immediately accessible to the learner when he needs them would provide the required flexibility and individualization. This is of major importance in the teaching of psychomotor skills, where students differ so greatly in their conceptaul and digital abilities. The student could proceed on his own in accord with his own capabilities. Since information can be dispensed electronically, there will be more dialogue and communication between teacher and learner, and more time can be devoted to individual learning problems.

Computer-assisted instruction, however, is only one of a number of computer applications that can improve dental education. Many of you are involved in using computers to automate student progress records and to continually evaluate students' clinical performance. After refinement of this information, it should be possible to develop learning curves in the motor skills area. Such curves are a fundamental requirement if we are eventually to let a student proceed independently and yet precisely measure his learning. Many of you also are involved in individual test analyses; why not also attempt to establish a central data bank of test items which could be available to faculty throughout the country? This would have a significant benefit: better and certainly more objective tests, with considerably less time and effort required from overburdened teachers. There are many other computer uses which can directly improve instruction. For example, learning environments can be simulated with controlled variables for the study of learner-instructor interaction.

Let us assume now that a student has been selected for dental school, has had the freedom to complete the curriculum in two years and is happy and successful in private practice. The computer will still have a role: to ensure that this dentist is provided with the information needed to keep him up to date. It should be possible for his educational needs to be continually diagnosed and treated, possibly through strategically located computers, on the basis of his type of practice, his location, and the specific characteristics of the population he serves. It is likely, because of the knowledge explosion, that continuing education will have to be managed in this way, and with this degree of selectivity, to maintain the skills of practicing dentists.

The implication of computers for dental education are indeed far-reaching. Billing, filing, payroll, inventory control, and a host of routine problems can now be handled more efficiently by computers. These functions, although only indirectly related to the instructional process, have a distinct influence on the educational economy.

One computer application which emphasizes the interrelationships between students, teachers, facilities, and the public deserves special consideration. This is, as I mentioned earlier, its use to improve the delivery of care, specifically within an educational setting. If dental schools are to continue attracting patients from the general population, then a great deal must be done to increase the efficiency with which these patients receive treatment. But this must also be done in a way that considers the students and learning first. Part of the problem is in scheduling; much can be done to implement comprehensive patient care, and, at the same time, make optimal use of the student's time, the faculty's time, the patient's time, and the facilities. The application of operations research and systems analysis techniques to improve the efficiency of clinical operations is severely needed.

To conclude, there are two major purposes of this Conference. First, to stimulate communication and encourage cooperation among the schools now using computers. Second, to provide some documentation which may assist other schools who are contemplating the use of computers. If these aims are achieved, at least in part, then the Conference will have been worthwhile. The future holds exciting possibilities if we build progressively on one another's knowledge and experience.

PART 1

Invited Addresses

Part 1. INVITED ADDRESSES

INTRODUCTION

This section contains seven papers based on formal adddresses made at the conference. The first three (Stolurow, Grubb, and Starkweather) are statements by educators who have been active for several years in the area of computer-assisted instruction (CAI), primarily outside the context of dental education. The remaining papers deal with the use of computers in four areas of dental education—admissions (Ginley), CAI (Tira), dental school operations (Crandell), and evaluation of clinical coursework (Ehrlich).

Lawrence M. Stolurow prefaces his description of CAI programs and projects at the Harvard CAI Laboratory with a discussion of educational technology and the modes of interactive instruction available in CAI. Stolurow is interested both in providing interactive instruction and in using CAI as a vehicle for conducting basic studies in learning. He illustrates possible instructional strategies with samples of student-computer dialogue taken from CAI programs in medical and dental education at Harvard.

Ralph E. Grubb of IBM characterizes CAI as the use of a computer to improve the student's interaction with materials, subject matter, and teachers, with stress placed on the nature of the interactive process. Eleven modes of interaction are identified, ranging from drill and practice to exploration. He notes that since we are unable to individualize instruction successfully in a prescriptive fashion at present, a more fruitful approach, at least on an interim basis, might be to relinquish program control to the learner to make selections of experiences within a learning space or content area according to his own understanding of his needs. Grubb enters a plea for serious consideration of the exploratory or "learner-controlled" mode, citing studies which demonstrate its advantages. He also reviews briefly the resources needed in a successful CAI effort and sketches some avenues that future CAI work may take.

John A. Starkweather of the University of California, San Francisco Medical Center, describes the operation of a CAI system (PILOT) within a multipurpose computing center. Although the diverse demands of the user group make it difficult to concentrate resources on any one aspect of the services offered, PILOT, actually an interactive, conversational programming language, has enjoyed considerable success. PILOT affords a variety of instructional modes, including simulation, through its natural language processing capabilities. Descriptions of patient simulation programs which are intended for use in teaching medical interviewing skills are included, as well as examples of programs which illustrate some of the other instructional modes possible with PILOT. Starkweather outlines several areas of need, emphasizing in particular the desirability of translating curriculum elements from one CAI system to another. Compatibility of this sort would have several advantages, including multiple evaluation of new materials, joint curriculum development, and the sharing of existing materials.

Thomas J. Ginley of the American Dental Association considers the growing problem faced by dental schools in processing applicants for admissions. An increase of nearly one-half in the number of candidates is expected over the next five years, accompanied by a corresponding increase in the number of documents that must be handled by admissions committees. To reduce the burden now placed on the individual dental school in processing applicant records and in selecting an entering class, Ginley proposes three alternatives, ranging from a document clearinghouse to a central computerized selection system. His paper makes clear the scope of the problem and the need for developing a procedure superior to the one now in use. Whatever form such a system might take, it is clear that the cooperation of all dental schools is necessary if it is to be successful.

Daniel E. Tira describes experiences with CAI courses in physiological chemistry (14 hours in length) and oral cancer recognition (4 hours) at the Ohio State University, College of Dentistry. The first course features a tutorial, self-evaluative format which has gained acceptance by students in spite of the novelty of format and the severe scheduling problems encountered. The second is an attempt to simulate the decision-making processes which might occur in practice in the diagnosis of an oral lesion. The program permits the student to develop a patient history, conduct a physical examination, and request laboratory tests in an unstructured fashion. The student's differential diagnosis is evaluated and either confirmed or rejected with relevant feedback until the correct diagnosis is made. The initial resistance of dental students to these courses bears witness to the problems faced by a lone self-instructional course when it is injected into a curriculum in which self-evaluation and flexible scheduling are traditionally minimized. On the positive side, the project demonstrates that CAI, often narrowly viewed as a means of supplementing or supplanting classroom instruction, can provide another and equally valuable benefit, that of functioning as an impersonal and unflagging evaluation system. In this project the CAI system provides (1) self-evaluation to the student, (2) information for faculty upon which to base tutoring and counseling, and (3) a source for subject matter validation for the curriculum specialist.

Clifton E. Crandell reports on the work in progress at the University of North Carolina, School of Dentistry to introduce total patient care into the clinic experiences of dental students. Until now, the requirement of developing technical skill has been incompatible with comprehensive patient care because of the complexity of scheduling student clinic experiences within such constraints as the needs of the patient, the availability of faculty specialists and facilities, and the level of ability of the individual student. Computer-based operations research methods appear to offer one solution to the scheduling problem posed by comprehensive patient care. A scheduling model based on linear programming techniques has been used with a limited number of students and preselected patients in a pilot study. Some preliminary results are discussed along with plans to extend the approach to include all students and clinic patients at North Carolina.

Paul Ehrlich describes the recordkeeping system in operation at the University of Southern California, School of Dentistry for evaluation of students' clinical performance. Measures of performance include grades, the quantity of work performed, and a composite measure based on both quality and quantity. Among the advantages of the computerized system are the rapid provision of progress reports to students and faculty, the automatic compilation of grades, and increased revenue from clinic operations as a by-product of tighter controls. Ehrlich discusses some of the practical problems which occur in implementing and operating a system of this type.

LAWRENCE M. STOLUROW is Director, Computer-Aided Instruction Laboratory, Harvard University. He holds a B.A. from the University of Minnesota, an M.A. from Cornell University, and a Ph.D. in experimental psychology from the University of Pittsburgh. Programs under his direction at Harvard deal with psychological foundations of teaching and learning; the development, application and evaluation of computer-assisted instruction (CAI); and the training of educational personnel for research in and implementation of CAI. Previous positions included serving as the head of the Training Research Laboratory, University of Illinois, and directing a research unit on the training of technical personnel within the Air Research and Development Command, U.S. Air Force. His publications include more than 80 articles or chapters dealing with the psychology of learning, motivation, and the measurement of behavior. He is author or co-author of *A Guide to Evaluating Self-Instructional Programs, Computer-Assisted Instruction in the Health Professions, Readings in Learning*, and *Teaching by Machine.*

LEARNING IN THE MEDICAL/DENTAL SCHOOL ENVIRONMENT

Lawrence M. Stolurow
Harvard University

I am pleased to have this opportunity to share with you some thoughts about learning in the medical and dental school environment.

Dental and medical educational programs, particularly at the undergraduate level, are currently undergoing extensive review and examination. As Dr. Podshadley has indicated, the need for change is patently clear. He has mentioned several factors contributing to the urgency of the situation. The three most critical from my point of view are: the "information explosion" in the basic sciences; the need for increased services to meet population increases; and student insistence upon more relevant and meaningful school experiences. The problem for the schools is to respond to these requirements for change in an effective and meaningful way while at the same time maintaining academic excellence.

Dentistry and medicine are no strangers to change. There has always been the problem in these two disciplines of accommodating new developments and concepts and translating new

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The work reported in this paper was conducted with the support of Office of Naval Research Contract No. N00014-67-A-0298-0003 and U.S. Public Health Service Contract No. PH 108-69-18.

findings and theories into practical applications. The need to do these things is not new. What is new today is the tempo and magnitude of the changes. Both have increased several-fold over the past few decades. In fact, it is currently estimated that new knowledge in medicine is increasing at a rate of nine percent per year, and the rate is increasing. Dr. Podshadley's projections suggest the rate of acceleration we can expect. It is these dimensions of the present problem that are different from the past. It is these factors that are causing the difficulty.

One approach to the solution of these problems is to turn to technology to accelerate what is now being done. Another is to examine the problem in the light of new concepts and methods of instruction to determine whether a new approach might be taken. The depth and extent of the problems is such that the mere use of isolated devices such as films, television, and tapes is not likely to solve them. The nature and complexity of the problems suggest that a more useful approach would be a continuing program of research that utilizes an integrated instructional system rather than a collection of devices. It is quite clear that both a conceptual and a research approach are needed to solve the problems, but that the institutional mechanism to bring it about in a systematic way is only just emerging.

There is also an attitudinal obstacle. Many faculty members do not consider it necessary to conduct *in vivo* studies of educational problems. Moreover, not all health scientists feel that the problems of instruction are amenable to a scientific approach. Experience, however, suggests that this is just what is required if change is to mean progress. Research is as much needed for the solution of educational problems as for the solution of substantive ones in the sciences. Educational problems must be identified, hypotheses formulated regarding their solution, and a plan developed and carried out to determine the answer. It can also be argued that the students who participate in educational studies are taking a smaller risk than those who do not if one accepts the possibility that students taught by methods presently in use are not necessarily being taught by the best methods. Participation in educational studies can be immediately advantageous to the student, and the results will help indicate the nature of the changes that will make instruction better for the next group. Consequently, the profession and the patients both benefit from research and development in instruction.

The idea of experimentally testing ideas about instruction is winning increased acceptance. However, the scientific study of the instructional problems in dentistry and other health areas requires a laboratory, professional personnel, and a program. A team of specialists from several professional fields is needed so that scientific methods can be used to study the problems of learning and technology can serve the process. The concepts, methods, and tools for this approach are becoming available, but they must be developed within an educational context, i.e., there must be a symbiotic relationship between the host field and educational technology.

EDUCATIONAL TECHNOLOGY

Many think of educational technology as simply the use of audio or visual devices in instruction. While the application of educational technology does involve hardware, including computers, the use of these devices does not adequately describe the field. Media are one ingredient of a systematic educational technology. Another, and critical, ingredient is psychology. The concepts and principles used to determine the organization of a course and the teaching strategies to be used are of greater potential value than the devices that implement them. The third ingredient of educational techology is research—the use of experimental methodology for decision making, quality control, and program improvement. Only research provides the experimental data which can be used to improve the instructional system and its use.

A critical element of any learning system is the applied psychology of learning, retention, and transfer. As Dr. Podshadley mentioned, dentistry is concerned with perceptual-motor learning as well as cognitive psychology, problem solving, reasoning, and thinking. Concepts from these areas provide guidance for the design of instructional materials. The areas of testing and evaluation, including the measurement of aptitudes and personality, provide a rational basis for assessment and for carrying out specific types of instruction for individual students.

The process of applying psychology to instruction has definite steps. It begins with the definition of certain behavioral objectives for the instructional program. This means that statements are formulated to describe what a student will be able *to do* when he has successfully completed the course of instruction being prepared. Behavioral objectives are specific statements. They are not general descriptions of the course and its philosophy.

To ensure that the learner gets only what he needs during learnings, his instruction begins with a pretest. The pretest determines the amount of knowledge or skill a student has that is relevant to the instruction he is about to receive. After instruction, the student is given a post-test, which provides the teacher or system with the information needed to determine the amount of learning that has taken place. The primary measure of success or failure of the instructional system is derived from the differences in pre- and post-test scores.

Although these tests are essentially an achievement test, they are not constructed in the conventional way. Unlike most achievement tests, they are *criterion-referenced.* This is another way of saying that the items which make up the tests are in a one-to-one correspondence with the list of instructional objectives. The test items cover all of the things which the program is designed to teach. Failure on an item pinpoints what the student did not learn.

Another critical part of the plan for an instructional system is its instructional strategy. This is the means by which the organization of the instructional material, including the way in which it relates to the learner, is achieved. An instructional strategy is a set of rules that determines the way in which a source of information, such as a teacher or instructional program, responds to the student. Even noninteractive forms of instruction such as lectures, films, and television,, vary in the way the information is organized for presentation to the student. However, a strategy for interactive instruction is much more complicated; several methods of organization are planned so that the most appropriate one can be used for each student, depending upon his pattern of responses.

In interactive instruction, information may be presented in a variety of ways. For example, it may be presented in an *inductive* manner or in a *deductive* manner. Also, each of these forms of presentation can be prepared so that the speed of the interaction is more or less rapid and proceeds in less or greater depth, depending upon the student's performance. A sequence of instructional units designed to teach a set of objectives is organized differently whenever different instructional strategies are used. For example, elements of a strategy could be the use of review procedures when a student makes a particular type of error, the use of review following a discussion of a set of topics, the use of a correction procedure when errors are made, and the use of evaluative feedback. The term strategy is used here to mean the method of organizing instructional experiences, and the manner of relating information to the student. The means of achieving any organization of experiences is usually a set of rules that guide the interaction. The rules are stated in a contingency form, as "if . . . then . . ." statements. A number of rules may be used together to provide a particular strategy. One set may determine the sequence, another the type of feedback, another the wording of the presentation. Usually more than one rule is used in structuring an interactive strategy. In principle, however, the concept of a strategy does not require more than one rule.

Instruction is often said to have a "style". This term generally includes characteristics of the instructor's behavior such as his personality and manner of relating to students. Style does not just refer to the rules of presentation. From the point of view of the educational technologist, the rules for selecting examples, the rules for sequencing topics, and the rules for evaluating student performance are the kinds of rules generally included in the description of a strategy.

The dictionary definition of the term strategy refers to military planning of an interaction with an enemy. There is no attempt here to use the term in that sense. Rather, it is used in educational technology in the sense it is used in game theory, as a set of rules that determine the nature of an *n*-person interaction. These rules are explicit and often formalized statements. The coding of computer-aided instruction (CAI) programs defines the nature of the interaction and is designed to produce a payoff in student performance.

INDIVIDUALIZED INSTRUCTION

While it has not been possible in the past to conceive of individualized instruction on a large scale, the introduction of the computer as a multiple-access, interactive device has made it possible to demonstrate that this approach is both feasible and practicable.

It is important to define the meaning of individualized instruction as it is used here, before describing the various modes of instructional interaction. Individualized instruction is instruction that is prescriptive. The instructional interactions in which an individual engages are selected (prescribed) on the basis of his performance. This prescription is based upon the most relevant data available to the decision maker. The decisions to be made relate to both the content and the strategy of the instruction. Individualized instruction does not refer to instruction in isolation, which is its usual connotation. The prescription given a student may include a period of individual instruction at a CAI console but it could also be the presentation of a film, an interaction with a group, or an interaction with a teacher.

Interactive instruction is instruction that engages the source and student in a dynamic process; the learner does something and the source does soemthing. The two are interrelated in that the things which the student does determine things which the source does. The use of the computer in interactive instruction represents a qualitative difference from the use of programmed instruction, and it is a significant innovation in the medical and dental school environment. Both programmed instruction and computer-aided instruction depart from the conventional use of media such as books, films, and television in that the student is continuously responding and receiving feedback, but it can also include in its branching these kinds of experiences. The flexibility of the CAI system, and its ability to branch, differentiate it significantly from programmed instruction. A CAI system processes according to a logic or strategy. It can do this selectively, with speed, and for a wide variety of responses from a number of students. It also can provide the learner with information about his performance at any point for either motivational or directional value.

One of the simplest modes of interactive instruction is the *problem-solving mode.* In this mode the student is presented with a problem which he processes by defining the logic or procedure he will use to solve the problem. He then specifies this to the computer through a program which he prepares and provides with appropriate data. His program is a description of his solution. The computer processes the program and provides the student with the solution. If the solution is correct the student has described a satisfactory solution. A common purpose of the problem-solving mode is to build up the student's skill level in the use of problem-solving procedures and appropriate concepts.

In the problem-solving mode of instruction one of the teaching objectives is to determine the way in which the individual organizes his solution. It is the logic of his approach to the problem that is critical. In order to utilize this mode of instruction in its most common form, the student learns the language which the computer uses. However, it also is possible to develop programs that allow the student to solve problems in natural language.

The *inquiry mode* of instruction is another mode which puts the student in control. He forms his questions using natural language, or in some more limited way. A thesaurus is often used to restrict the set of terms the student can use. The system responds by retrieving the information requested and presenting it to him at the terminal. In this mode the student has to learn very little about the way computers process, but he does have to learn how to ask the right kind of questions. Inquiries at a computer console must be formed in a way that allows the system to identify the critical elements in the data bank that are being sought. In the medical context, this kind of inquiry training can be related to the mastery of a basic skill that is useful in diagnosis.

The *drill and practice mode* is one of the most widely used modes at the present time. A recent summary* of CAI work reveals that the use of this mode of instruction in elementary school arithmetic and in college-level Russian can be very effective. It is a mode that is readily adapted to a CAI system. However, it requires the commitment of personnel to the development of instructional programs. This mode is used primarily to teach students a particular set of skills that tie into a program. The student repeats a particular sequence of steps until he reaches a specified level of proficiency or uses up his allotted time.

Another mode of interactive instruction is *gaming*. In this mode, a realistic problem is presented and the student is asked to make decisions. These decisions are processed and the outcome is communicated to the student. The objective of the game is to have the student learn a set of relationships between terms that define problems and those that describe the results when various decisions are made. In gaming, the computer is programmed so that the output associated with any input is realistic, in the sense that it could occur in the context to which the game pertains. In actuality, the output generally is determined by a random generator which selects a result from a set of possiblities.

Simulation is different from gaming in that the system has

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*Suppes, P. & Morningstar, M. Computer-assisted instruction. *Science*, 1969, 166, 343-350.

stored within it a model of some real event system which the student is trying to understand. In a simulation, relationships are critical. These are represented by the model which is used to determine the consequences of decisions. The student knows the way in which events are presented and the ways in which the outcomes appear. What he does not know is the nature of the complex set of relationships between events, decisions, and outcomes. The system may or may not teach him the model as such, so that he knows it in formal mathematical terms. It is more likely to be used to build an intuitive dispositon which permits the student to perform "as if" he knew the formal relationships. Sometimes, however, it is the objective of simulation to actually teach the nature of the model which the system is using to provide the simulation experiences.

The *tutorial mode* of instruction is a level of instruction that not only involves dialogue but also the other previously described modes on a selective basis. For example, the consequences of a student's response to a question may be a drill and practice session to build up some critical skill. On the other hand, the student may be branched to a game or to a simulation. In the tutorial mode any or all of the other modes of instruction can be used, depending upon the needs of the learner and the objectives to be achieved.

A COMPUTER SYSTEM FOR INSTRUCTION

The Harvard Computer-Aided Instruction (CAI) System is shown in Figure 1. In addition to the computer, which in this case is an IBM S 360, Model 65, the system includes equipment to read the data from the cards, tapes, or disks that introduce instructional sequences into the system; the computer-aided instruction language; and the students. The lower half of the figure describes the teleprocessing equipment used. It provides access to the system simultaneously from a number of different users in any location equipped with a telephone. A variety of student consoles can be used. Some provide only a typewriter as the input and output device. Others provide the student with audio and visual experiences through auxiliary devices that present slides and audio tapes under computer control. These presentations are synchronized with the program so that particular slides and tape segments are utilized at appropriate points in the instruction. The system is capable of branching the student from one part of the program to another, depending upon information about the student and his past performance.

The following sections describe four CAI programs in the health sciences. Several are currently running on the Harvard CAI System. The preparation of such programs serves a dual purpose, since the CAI system can be used to provide interactive instructional experiences and to do basic research on learning and teaching.

* * *

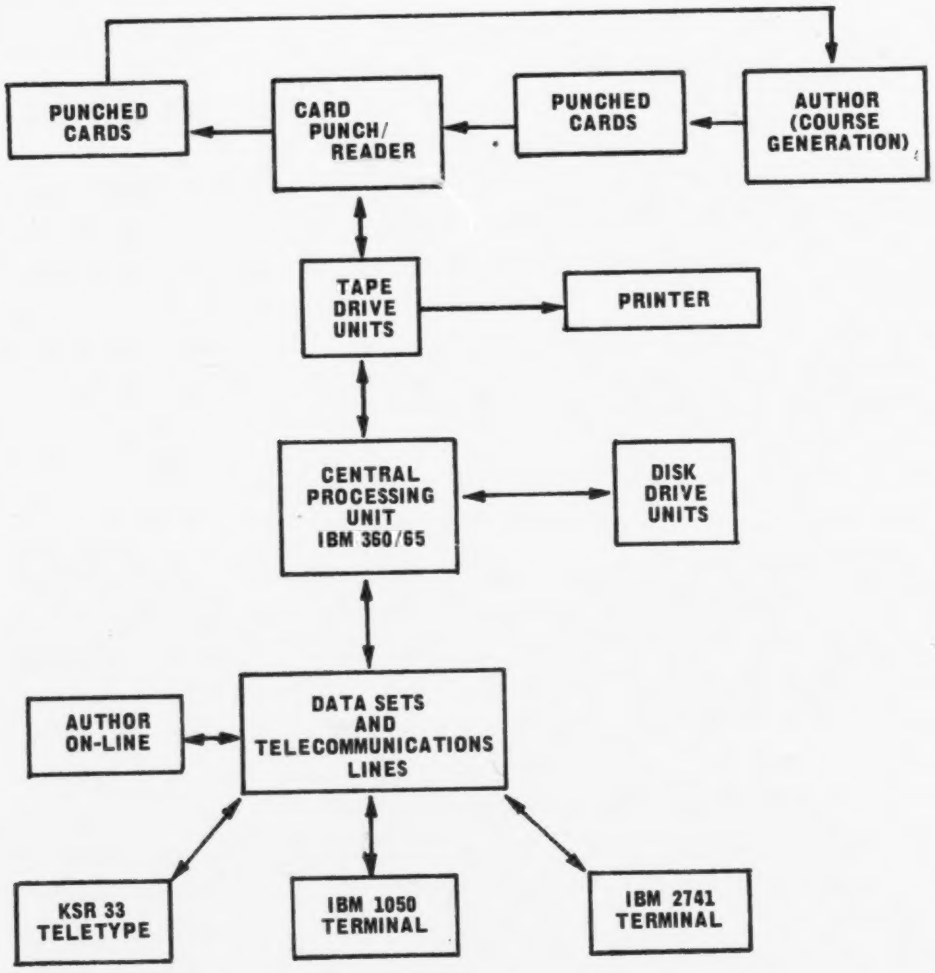
PUNCHED CARDS
CARD PUNCH/ READER
PUNCHED CARDS
AUTHOR (COURSE GENERATION)
TAPE DRIVE UNITS
PRINTER
CENTRAL PROCESSING UNIT IBM 360/65
DISK DRIVE UNITS
AUTHOR ON-LINE
DATA SETS AND TELECOMMUNICATIONS LINES
KSR 33 TELETYPE
IBM 1050 TERMINAL
IBM 2741 TERMINAL

Figure 1. The Harvard University computer-based interactive instructional system.

* * *

Socratic Dialogue and Laboratory Simulation in Pathology*

Dr. Earl E. Hellerstein, a pathologist at the Harvard Medical School, has developed with the assistance of personnel at the Harvard CAI Laboratory a series of nine CAI pathology lessons. The course is presented on an IBM 1050 audiovisual terminal. In the course, slides are projected on a rear projection screen mounted on the surface of the desk at which the student works. The screen takes the place of a laboratory microscope. A tape recorder can be played with or without earphones for the convenience of the learner and the others present in the room.

The primary objective of these lessons is to teach students to identify, from transparencies, critical characteristics of such organs as heart, artery, vein, lung, spleen, bone marrow, and lymph. In addition, the material was designed to teach students to connect morphological patterns, as represented by projected color transparencies of micorscopic slides of fungal diseases, with specific pathological lesions. The programs also teach various basic concepts in pathology such as predisposing factors and dissemination. In short, the student is taught a heuristic approach to the processing of information presented in a transparency to help him determine what disease process is present in a tissue.

More specifically, the nine course segments (Path 1 to Path 9) were developed for the second-year medical student studying fungal diseases in the pathology laboratory. They were designed to produce six important types of behavior. The first is the *identification,* from transparencies, of critical information for the diagnosis of pathogenic entities. The second is to teach the *recognition* of variations in histological response to disease. The third is to *describe* tissue responses. The fourth is the *specification* of methods (tests) to confirm a diagnosis. The fifth is the *naming* of factors that determine the communication of disease. The sixth is the *naming* of predisposing factors involved in the acquisition of disease.

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*The following description is based on Technical Report No. 3, CAI—Socratic dialogue and laboratory simulation in pathology, 1967, Office of Naval Research Contract No. N00014-67-A-0298-0003, Harvard University, by Earl E. Hellerstein, Terrill A. Mast, and Lawrence M. Stolurow.

The general teaching paradigm used is the Socratic dialogue with supplemented branching strategies. A segment is defined by the existing course pattern. Each one begins with the student's self-controlled viewing of slides of a series of magnifications of a section of a diseased organ. For example, in Path 1, the student sees a 1X, 4X, 16X, 40X, 100X, and a 200X phase magnification of the spleen infected by histoplasmosis. He is allowed to study each magnification as much or as little as he likes; he controls the time he uses. He has the option both here and at various other places in the course of viewing the entire set of transparencies at his own speed, at "flash" speed, or with no review. The system allows him to inquire or to retrieve information in which he is interested at any time. In addition, he interacts as an individual in a Socratic dialogue through his verbal responses and through the questioning of the system which branches to materials that prompt and help him when he has difficulty.

Having studied the transparencies, the student's first task is to name the infected organ. If his identification of the organ is correct he moves ahead in the course, but if his identification is incorrect, he is automatically branched to a section of dialogue and a series of remedial frames requiring examination, analysis, and response. The objective of this series of frames is to concentrate his attention on the critical characteristics or qualities of the section of tissue that reveal the class of organ, organ system, and specific tissue that he is viewing. This dialogue calls upon information which he should have learned earlier in his medical education but which he appears not to have applied to this task of identifying the organ from the transparency. The dialogue is designed to require retrieval and transfer of information previously taught, but not necessarily used in the context of a laboratory. In one way or another, depending upon the student's response to each question about what he sees and what it means, he moves or is led to a correct organ identification before going on to a new one.

A student-computer dialogue is reproduced below to illustrate one of the paths which the interaction could take. As the course is currently programmed, different paths are possible, and the one that unfolds depends upon the student's responses at several points.

As this dialogue unfolds, the student has just viewed a sequence of transparencies—in this case a series of 1X, 4X, 16X, 40X, 100X, and 200X phase transparencies of spleen with histoplasmosis.

Computer: DO YOU KNOW WHAT THIS ORGAN IS?

Student: I think so

C: THE INSTRUCTIONS TYPE YES OR NO MEAN:
TYPE YES OR NO.

S: yes

C: (computer reprojects 40X magnification and types)
40X AGAIN. OK, WHAT IS THE ORGAN?

S: I think it is lymph node

C: FAIRLY REASONABLE CHOICE, BUT WRONG.
LET'S START FROM SCRATCH. (computer projects
1X magnification) DO YOU THINK THIS IS A
HOLLOW VISCOUS? YES OR NO?

S: no

C: THIS IS NEITHER MUCOSA NOR MUSCULARIS,
HENCE THIS IS NOT GUT, UTERUS OR
FALLOPIAN TUBE, URETER OR URINARY BLADDER.
ALSO IT IS NOT HEART, ARTERY OR VEIN.
(computer reprojects 200X magnification) THEN
IT IS A SOLID VISCOUS. WAS IT LIVER?

S: no

C: CORRECT. THERE ARE NO PORTAL TRIADS, NO
CORD CELLS . . . SO IT IS NOT LIVER. THE
ORGAN CONTAINED MANY SINUSOIDS AS WELL
AS A FAIR NUMBER OF RBC'S. THESE SUGGEST
AN ORGAN OF THE RETICULOENDOTHELIAL
SYSTEM; NAMELY THE . . .

S: marrow

C: WRONG. BONE SPICULES, FAT CELLS, AND
HEMATOPOIESIS WERE ALL ABSENT.
TRY AGAIN.

S: spleen

C: THAT'S RIGHT. IT'S SPLEEN. (computer reprojects 16X magnification; this time it contains pointing arrows) UPPER ARROW — ONE OF THE FEW GERMINAL FOLLICLES IN THIS DIFFICULT H&E SLIDE. LOWER ARROW — ARTERIOLE. THESE HELP TO IDENTIFY THE ORGAN AS SPLEEN. NOTE THE VALUE OF LOW POWER. PRESS EOB WHEN READY TO MOVE ON. (EOB means "end of block" and signals "I am through" to the computer)

Another possible line of dialogue follows. It would have been presented if the student had incorrectly answered "liver" when asked about the organ.

Computer: (computer projects 40X magnification) 40X AGAIN. OK. WHAT IS THE ORGAN?

Student: liver

C: NAME ONE HISTOLOGIC FEATURE THAT CHARACTERIZES LIVER.

S: portal triad

C: CORRECT. HEPATIC CORD CELLS AND THE VARIOUS STRUCTURES IN THE PORTAL TRIAD ARE CHARACTERISTIC OF LIVER. THE LIVER ALSO HAS A CHARACTERISTIC NORMAL "ARCHITECTURE". ARE THESE FEATURES VISIBLE IN THESE TRANSPARENCIES?

S: no

C: CORRECT. THE IDENTIFICATION OF LIVER THUS LACKS SOLID GROUNDING. NOT LIVER. DO YOU THINK THIS IS A HOLLOW VISCUS? YES OR NO?

S: yes

C: WRONG. THERE IS NEITHER MUCOSA NOR MUSCULARIS. HENCE THIS IS NOT GUT, UTERUS OR FALLOPIAN TUBE, URETER OR

URINARY BLADDER. ALSO, IT IS NOT HEART, ARTERY OR VEIN. (computer reprojects 200X magnification) THEN IT'S A SOLID VISCUS. WAS IT LYMPH NODE?

S: no

C: RIGHT. THE ORGAN CONTAINED MANY SINUSOIDS AS WELL AS A FAIR NUMBER OF RBC'S. THESE SUGGEST AN ORGAN OF THE RETICULOENDOTHELIAL SYSTEM; NAMELY, THE . . .

S: spleen

C: THAT'S RIGHT. IT'S SPLEEN.

These two examples illustrate that the path a student takes depends upon what his responses are. However, his path depends upon not only the immediately preceding answer, as with a "right" or "wrong" message from the computer, but also upon the student's previous behavior either in the course or in pretests (a student's responses are stored by the computer in counters). The student is branched to one of the predetermined options that the author anticipated. In the examples above, the student who originally identified the organ as *lymph node* and the student who originally identified the organ as *liver* were both taken through *approximately* the same set of error diagnostic frames, but not precisely the same set in terms of the text. When student A answers "liver" the program places a "1" in his number 2 counter. At various points in the error-diagnostic set, the computer asks itself what this student's original answer was. If his counter says he answered "liver" then it takes him one way. If the counter says he answered "lymph node" (stored as number 2, for example) then he goes to different material. If the counter says that he answered neither, he goes in still another direction.

As this program is written, the student's next task is to diagnose the disease of the organ. If the student thinks he knows the disease, the course may unfold in the following way.

Computer: OK. WHAT DO YOU THINK THE DISEASE IS? (Depending upon his response the computer will display different messages. For example, if his response does include the name of certain specified fungi, it will give him a list of certain broad categories of diagnosis. An incorrect category choice will cause the program to do one of two things, depending upon the answer he chooses. The first thing it can do is to continue the dialogue by going down the incorrect but logical path flowing from the student's answer. The program participates for a time in the student's stroll down a blind alley.)

THE DISEASE FALLS IN WHICH CATEGORY?

A. CIRCULATORY
B. NEOPLASTIC
C. BACTERIAL
D. VIRAL
E. PROTOZOAL
F. FUNGAL

S: b

C: IS THE NEOPLASM YOU HAVE IN MIND PRIMARY OR SECONDARY?

S: primary

C: THIS VIRTUALLY MEANS THAT YOU SAW EITHER A LUKEMIA OR A MALIGNANT LYMPHOMA. WHICH?

S: lukemia

C: NO PRIMITIVE HEMATOPOIETIC CELLS OR HUGE EXCESS OF ADULT WBC'S. NO MALIGNANT CELLS—NO NEOPLASM. SO—CHOOSE DISEASE CATEGORY FROM A TO F AGAIN.

Alternatively, the *second* thing the program can do is to immediately tell the student he is wrong and give him the correct answer.

Computer: THE DISEASE FALLS IN WHICH CATEGORY?

A. CIRCULATORY
B. NEOPLASMIC
C. BACTERIAL
D. VIRAL
E. PROTOZOAL
F. FUNGAL

Student: e

C: IF YOU HAD A PARTICULAR PROTOZOAL IN MIND, YOU COULD BE RIGHT. ACTUALLY, THIS IS A FUNGAL DISEASE.

This program utilizes *correction procedure.* Whether the student chooses correctly on his first attempt or only after excluding others, he is told the correct answer or he will determine that this is a fungal disease and will be shown the list that follows.

Computer: WHICH ONE OF THE FOLLOWING FUNGAL DISEASES DO YOU PREFER?

A. ACTINOMYCOSIS
B. BLASTOMYCOSIS
C. CANDIDIOSIS (MONILIOSIS)
D. COCCIDIOIDOMYCOSIS
E. CRYPTOCOCCOSIS (TORULOSIS)
F. HISTOPLASMOSIS

The student's answer is treated the same way as his answer would have been had he answered affirmatively when asked if he knew the disease, and subsequently volunteered one of the above diagnoses. Suppose, for illustrative purposes, the student selects "blastomycosis" as the diagnosis. Then he would type "b". The resulting dialogue is illustrated below.

Student: b

Computer: (computer projects 100X of a blastomycotic lesion and then types the following question) WHAT DISEASE DOES THIS SLIDE SHOW?

S: BL astymocosis (In these programs, typing errors are ignored.)

C: YES. THIS IS BLASTOMYCOSIS. BUT THE ORIGINAL WAS NOT. STUDY THIS TO CONTRAST WITH THE ORIGINAL. WHEN YOU ARE READY TO LOOK AT THE ORIGINAL AGAIN, PRESS EOB.

This is, in our view, an interesting teaching strategy. It assists the student in his own error correction by letting him see the slide he mistook for the one he was asked to identify.

In the example above, the student again makes an incorrect diagnosis and receives a remediation treatment specific to his response. In this particular segment of the program, the student can err only three times. After the third round he is given the correct diagnosis and the program proceeds to new material. After the correct diagnosis of histoplasmosis is reached there follows a consideration of systemic histoplasmosis.

Computer: IN A MINORITY OF CASES (USUALLY CHILDHOOD) THE DISEASE MAY NOT STAY LOCALIZED TO THE LUNG (AND ITS NODES). IT IS THEN SAID TO BECOME . . .

Student: disseminated

C: THAT IS RIGHT. IT BECOMES DISSEMINATED OR SYSTEMIC. ORGANS OTHER THAN THE SPLEEN SHOULD BE INVOLVED IN SUSTAINING HISTOPLASMOSIS. NAME ONE.

S: spleen

C: PLEASE NAME ORGANS OTHER THAN SPLEEN.

S: lymph node

C: OK. NAME ANOTHER.

S: heart

C: WRONG. TRY AGAIN.

S: liver

C: OK. NAME ANOTHER.

S: node

C: YOU ALREADY NAMED THAT ORGAN. NAME ANOTHER.

S: bone

C: WE WILL GENEROUSLY ASSUME THAT YOU MEANT BONE MARROW. THE ORGANS OF THE RETICULOENDOTHELIAL (RE) SYSTEM INCLUDE: SPLEEN, LYMPH NODES, LIVER, AND BONE MARROW. THESE ORGANS ARE INVOLVED IN SYSTEMIC HISTOPLASMOSIS. PRESS EOB.

This course segment, Path 1, goes on to point out that histoplasmosis may mimic tuberculosis, and that the histoplasmin skin test can be used as further evidence in differential diagnosis. The course concludes with the reminder that other diseases may coexist with the infectious disease(s).

It can be seen that the strategy used in this course takes advantage of the capability of the system to synthesize a variety of instructional sequences upon demand and dependent upon the student's performance record. The demand is created by the retrieval of selected segments in the student's response history along with appropriate demographic data. These data are then used as a basis for decisions about what happens next. The student may be visually or verbally prompted; he may be assisted in learning a critical discrimination or a set of diagnostically useful associations.

One basic problem in interactive instruction is to determine how to synthesize from a set of possibilities the one teaching strategy that is most effective for a particular student. The process begins by speculating about factors that determine the gains students make in their performance on a post-test. This leads to the formation of hypotheses about critical factors in instruction. Then a set of alternative conditions is described and two or more strategies are used with similar students. Data are collected to determine the effect that each strategy has on students. If it turns out that a particular strategy works well with particular students, then the problem is to determine the means by which students are matched with the strategy that is best for them. There also is the companion problem of deciding, on-line, what rules to change when the student does not perform according to expectation.

Project TAPS: Teaching Anatomy with Programmed Schematics*

Project TAPS is concerned with a research question relating to the improvement of learning and retention of anatomical information through the type of visual display used in presenting information to the student. It is a study of the effectiveness of two different visual media in interactive instruction. More specifically, the visual materials are designed as perceptual aids to verbal learning. Schemata and representational diagrams are used to support a Socratic-style of dialogue which is designed to teach the topography, terminology, and concepts by means of a computer-aided instruction (CAI) system. The research aim is to determine the relative effectiveness of the visual information by comparing the performance of students after identical instructional programs which differ only in the visual materials used. The experimental comparison is made between a representational and a schematic drawing. Student performance on a test is used to identify the condition which results in the more efficient retention of information. In addition, correlations will be computed to determine whether different kinds of students, in terms of aptitude profiles, learn better from one or the other of these visual aids.

TRIGEM. The CAI course developed for Project TAPS is called TRIGEM and teaches the anatomy of the maxillary division of the trigeminal nerve. It consists of a total of 111 instructional frames and requires about one and one-quarter hours of student time. It is currently operational on the Harvard CAI system. The course can be accessed by either a standard teletype (model KSR 33) or an IBM 1050 terminal connected to a 103A2 data set. TRIGEM presents the student with information, both visual and verbal, about the trigeminal nerve. One objective of the program is to teach the student about nerves in general. Others are to teach the branch configurations of the trigeminal nerve, the names of the various divisions of the nerve, and the number of divisions that occur at each level.

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*This project was made possible by U.S. Public Health Service Contract No. PH 108-69-18.

Two programs, PD and PF, have been prepared and they differ only with respect to the supporting visual material. Pro-

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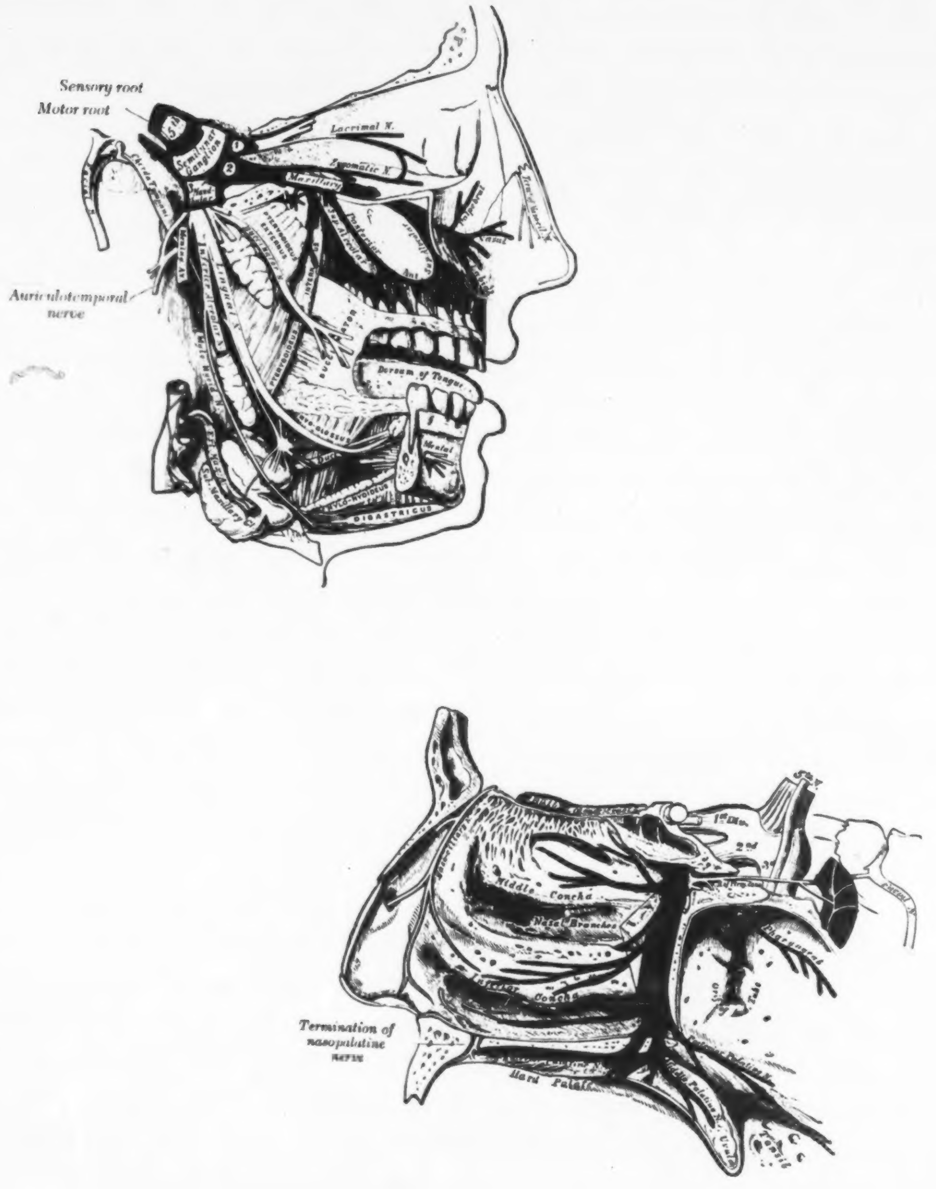
Sensory root
Motor root
5th
Semilunar Ganglion
1
2
Lacrimal N.
Zygomatic N.
Maxillary
Chorda Tympani
Auriculotemporal nerve
Lingual N.
Inferior Alveolar N.
Dorsum of Tongue
Mental
DIGASTRICUS
MYLO-HYOIDEUS
Sub-Maxillary Gl.
Termination of nasopalatine nerve
Middle Concha
Nasal Branches
Inferior Concha
Hard Palate
Middle Palatine N.
Posterior Palatine N.
Pharyngeal
Uvula
Tonsil
1st Div.
2nd
3rd
5th N.

Figure 2. The two representational diagrams used in Program PF of the CAI course TRIGEM.

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gram PF uses two representational diagrams (Figure 2) taken from *Gray's Anatomy*. Program PD uses a schematic diagram and identification key (Figures 3 and 4). These materials were dry-mounted on heavy cardboard and made available to students at the console.

Objectives. The main objectives of the program are as follows: (1) to enable the student to diagram the structure of the maxillary division of the trigeminal nerve; (2) to enable the student to label his diagram with (a) all the appropriate anatomical terms for the nerves, (b) the regions from which each branch originates, (c) the region through which it passes, and (d) the region or organ it supplies; and (3) to enable the student to answer verbal questions about each area described above.

Both programs are divided into four sections. The first section, which provides a description of the nerves in general, makes it possible for the student to *describe* the nerve tissue. It introduces the student to the trigeminal nerve and emphasizes the maxillary division. The objective of the second section is to teach the student to *name* the branch configurations of the maxillary division and to *sketch* the configurations, so that when he makes his sketch he will also be able to *identify* each of the several component structures of the nerve. The third section teaches the student the *names* of the nerves and the areas they supply. Upon completion of this section the student should be able to name each of the nerves and the areas they supply. Upon completion of the fourth section of the program, the student should be able to name the regions through which each of the branches of the maxillary division passes.

Types of Frames. Two basic types of instructional frames are used. One is denoted by the abbreviation RD ("Read") and the other by QU ("Question"). These terms refer to the codes used in CAILAN, the CAI language used on the Harvard CAI system. They give the system instructions for processing the text that follows each. An RD frame requires the student to simply read a paragraph. When he is ready to continue he presses the EOB—end of block—key which signals the system to proceed with the course. Some RD frames require the student to sketch some region of the trigeminal nerve. The booklet provided for this purpose contains black pages for the drawings, alternating with pages on which the correct configura-

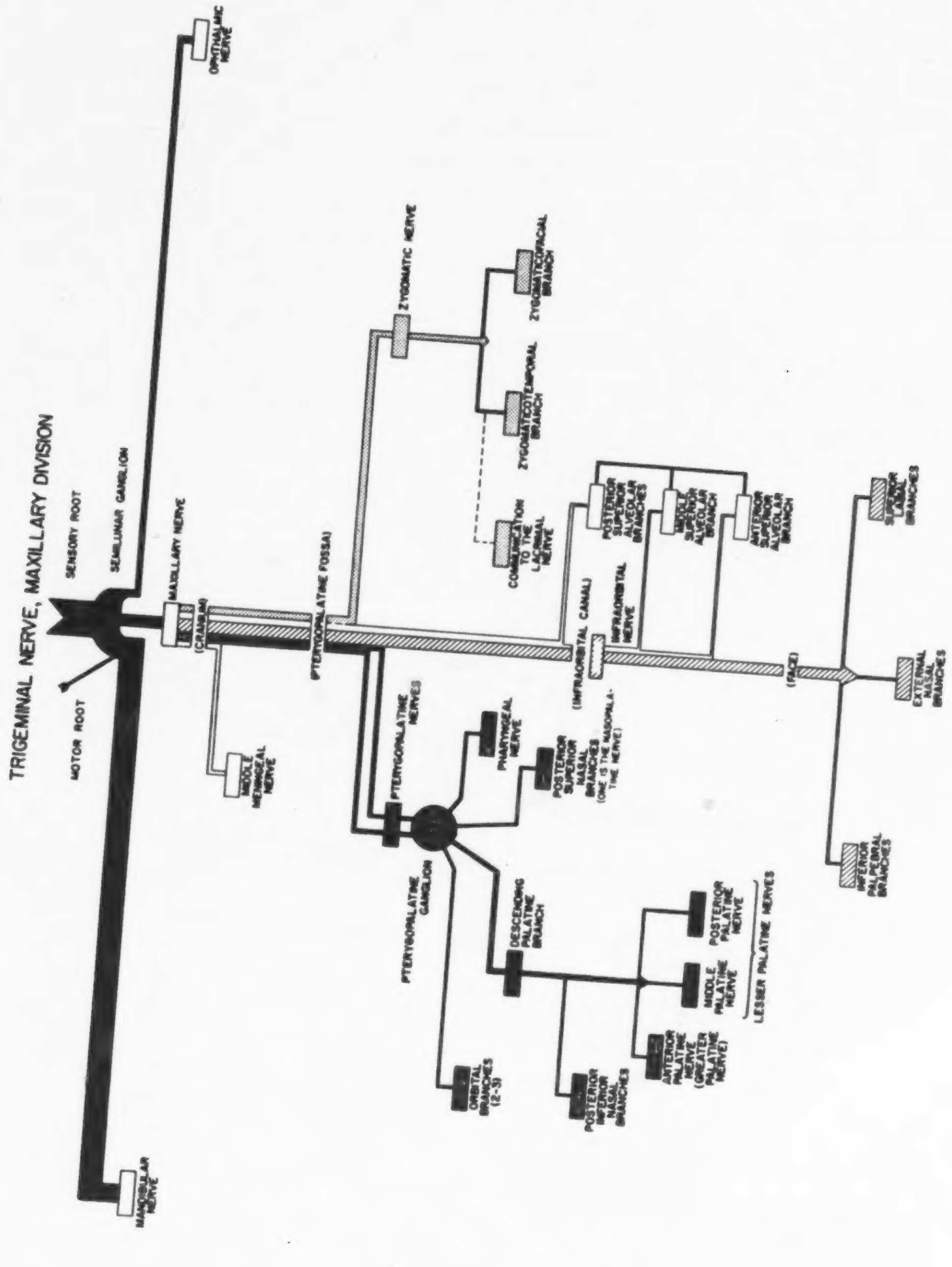
TRIGEMINAL NERVE, MAXILLARY DIVISION
MOTOR ROOT
SENSORY ROOT
SEMILUNAR GANGLION
OPHTHALMIC NERVE
MANDIBULAR NERVE
MAXILLARY NERVE
(CRANIUM)
MIDDLE MENINGEAL NERVE
(PTERYGOPALATINE FOSSA)
ZYGOMATIC NERVE
ZYGOMATICOTEMPORAL BRANCH
ZYGOMATICOFACIAL BRANCH
COMMUNICATION TO THE LACRIMAL NERVE
PTERYGOPALATINE NERVES
PTERYGOPALATINE GANGLION
PHARYNGEAL NERVE
POSTERIOR SUPERIOR NASAL BRANCHES (ONE IS THE NASOPALATINE NERVE)
DESCENDING PALATINE BRANCH
ORBITAL BRANCHES (2-3)
POSTERIOR INFERIOR NASAL BRANCHES
ANTERIOR PALATINE NERVE (GREATER PALATINE NERVE)
MIDDLE PALATINE NERVE
POSTERIOR PALATINE NERVE
LESSER PALATINE NERVES
(INFRAORBITAL CANAL)
INFRAORBITAL NERVE
POSTERIOR SUPERIOR ALVEOLAR BRANCHES
MIDDLE SUPERIOR ALVEOLAR BRANCH
ANTERIOR SUPERIOR ALVEOLAR BRANCH
(FACE)
SUPERIOR LABIAL BRANCHES
EXTERNAL NASAL BRANCHES
INFERIOR PALPEBRAL BRANCHES

Figure 3. The schematic diagram used in Program PD of the CAI course TRIGEM.

tions are printed.* The student draws on a blank page and then turns it over to disclose the correct answer. When he is satisified he knows a configuration, he presses the EOB key and the computer proceeds to the next frame. The student may take as much time on a question as he wishes before moving on. He is also given immediate knowledge of results. As soon as he responds he is given a performance standard against which to check his work.

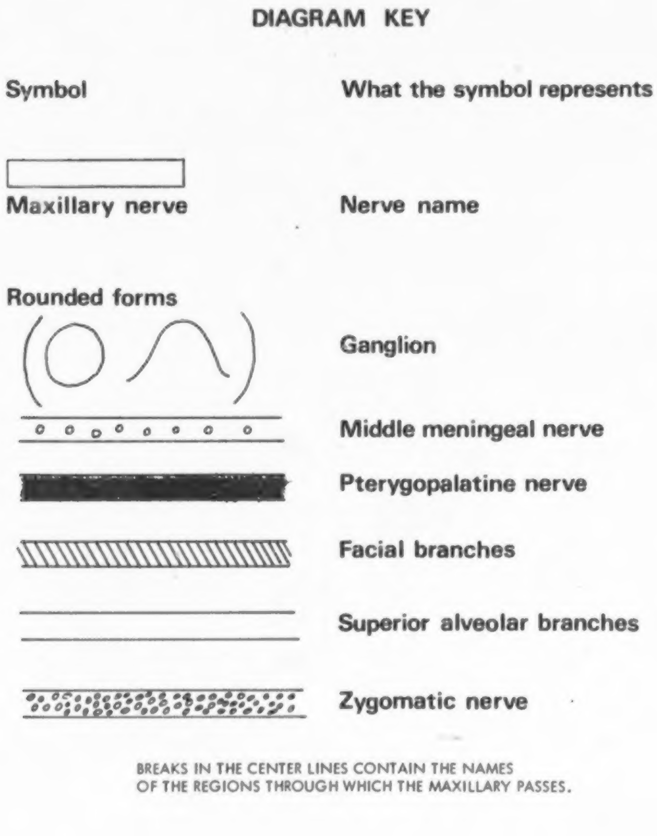
DIAGRAM KEY
Symbol
What the symbol represents
Maxillary nerve
Nerve name
Rounded forms
Ganglion
Middle meningeal nerve
Pterygopalatine nerve
Facial branches
Superior alveolar branches
Zygomatic nerve
BREAKS IN THE CENTER LINES CONTAIN THE NAMES OF THE REGIONS THROUGH WHICH THE MAXILLARY PASSES.

Figure 4. The identification key used with the schematic diagram shown in Figure 3.

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*Hard copy answer booklets were used to minimize student console costs, although it would have been more convenient and efficient to use a console equipped with a slide carousel or CRT.

Sample RD frames from section one are shown below:

Computer: NERVES ARE LONG WHITISH STRINGS OF CELL BODIES AND THEIR "APPENDAGES" WHICH CONDUCT MESSAGES FROM ONE PART OF THE ANATOMY TO ANOTHER. THE NERVE APPENDAGES ARE THE LONG PARTS WE USUALLY REFER TO WHEN WE SPEAK OF NERVES.

* * * * * * * * * *

Computer: NOW, WITHOUT LOOKING AT THE DIAGRAM, SKETCH THE DIAGRAMMATIC CONFIGURATION FOR ALL THE PTERYGOPALATINE NERVES. DRAW ON PAGE 11, AND THEN COMPARE YOUR DRAWING TO THE ONE SHOWN ON PAGE 12 OF THE BOOKLET.

Whenever the student is ready to move on, he presses the EOB key.

A QU frame requires the student to *type* a response. This response may be to fill in a blank or answer a direct question. If the answer is correct, the computer responds by typing CORRECT and then proceeds to the next frame. If the answer is correct but misspelled, the computer responds by calling the student's attention to his misspelling indirectly, by typing the word correctly in the response telling him he has answered the item correctly. This is called error-contingent prompting strategy and is used to preserve the student's morale and motivation. When the student's answer is incorrect, the computer tells him he is incorrect, gives him the correct answer, and proceeds to the next frame. This is called non-correct strategy. It was used throughout the program for all students, to maintain consistency for research purposes. Alternatively, the computer could have been programmed to require the student to make the correct response before allowing him to proceed to the next frame, as it was in the pathology program.

An example of a QU frame is as follows:

Computer: LOOK AT THE DIAGRAM. THE PTERYGOPALATINE NERVES APPEAR TO FORM THE . . . GANGLION. ACTUALLY THEY PASS RIGHT THROUGH THE GANGLION AND DO NOT FORM IT.

Student: pterygopalatine

C: CORRECT

This example illustrates the way in which the visual aid serves as a prompt for the correct response. The question calls the student's attention to the critical information, and the sequence used can aid in forming discriminations.

Another example of a QU frame, to which the student gives an incorrect answer, is shown below.

Computer: ONE BRANCH OF THE POSTERIOR SUPERIOR NASAL BRANCHES IS LONGER THAN THE REST. THIS BRANCH IS NAMED ON THE DIAGRAM AND IS THE . . .

Student: pharyngeal

C: INCORRECT. THE CORRECT ANSWER IS THE NASOPALATINE.

Note that the strategy used here is quite different from the one used in the pathology program, although the same one could have been applied with this type of visual material.

Tests. Before taking TRIGEM, students are given a test question booklet and an answer booklet. The test includes verbal items covering knowledge of the structure, function, and terminology of the trigeminial nerve. There is no difference in the pre- and post-tests. This procedure makes it possible to select frames from the total program that the student does not know although this was not done in the study being described.

All students also fill out an attitude questionnaire before and after the written test. This questionnaire measures the student's attitude toward CAI. It contains 15 statements and requires about one minute to complete.

Results. To date six students at Tufts University Dental School have taken the course, three Program PD and three Program PF.* Data on their performance have been used to improve the answer-processing procedures. When differences between pre- and pst-test scores for both groups were compared it was found that the group which took Program PD (schematic diagram and key) showed the larger gains on parts 1 and 2 and in total score. The group that studied with the representational drawing achieved larger gains on part 3, the section that teaches the names of the nerves and the areas they supply. Any further interpretation must await the completion of a second study, now in progress, utilizing a large student sample.

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*With the cooperation of Dr. William M. Feagans at Tufts University Dental School, five teletypes connected by telephone lines to the Harvard system were installed in a trailer adjacent to the school.

CAI in Ophthalmology*

The Vision Information Center (VIC), a system that combines instruction and information retrieval, was established in Boston on June 15, 1966 by Dr. Robert D. Reinecke and his associates at the Massachusetts Eye and Ear Infirmary and the Harvard Medical School, with the assistance of the Harvard CAI Laboratory. The philosophy behind the system is to give the user direct access to bibliographic information, thereby eliminating the intermediate step of consulting an information specialist. This is made possible by making available at the computer terminal instructional programs in ophthalmology which aid the user in specifying his request for information.

The user seats himself at a console, either an IBM 1050 terminal or a teletype. He is first given the option of taking a program called "Terminal" but if he is already familiar with the operation of the console he can bypass this program and go directly into the search mode. In addition to information retrieval, the user may also elect an instructional program in various areas of ophthalmology, e.g., strabismus, glaucoma, at any point in his search. While these CAI programs are self-contained units and may be used alone for other purposes, they are also intended to serve a user of the VIC system.

The CAI programs are available whenever a user needs help in making his request for information more precise. If, for example, he were to ask for information on the eye, he could retrieve the whole data base. The system could, however, display a diagram of the eye and ask the user to identify the parts in which he is interested. After recording that response, the system could ask him whether he is interested in function or structure.

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*This project is supported by U.S. Public Health Service Contract PH 43-66-911.

If the answer is function, it could then determine whether he is interested in normal or pathological functioning. Through such a procedure the information needs of the user are determined at a level which permits the system to identify an appropriate instructional program.

The next step would be to teach definitions and concepts relating to the user's area of concern. The idea is that some instruction preceding an inquiry from the data base can provide a more appropriate list of titles of publications than untutored inquiry. Also, instruction may be sought after articles have been identified so that the information they contain can be learned more efficiently.

When the user has narrowed down his initial inquiry he enters a thesaurus number from a manual available at the console. The system then types back the number of references available under that term. It then asks whether he wishes to continue or wants to select another term as well.

If he wants to continue, he enters a second number. This procedure can be used to narrow the search to the overlapping set. At any point the user may ask for the entire list of references. If the list contains less than twenty references, the entire list is printed out at the console. If there are more than twenty, the first ten are typed out at the console and the rest are mailed to him.

The VIC system has been described by Drs. Mary M. Eickhorn and Robert D. Reinecke in the *Journal of Chemical Docmentation* (vol. 9, No. 2, May 1969). This article includes a flow chart (Figure 5) showing the relationship between CAI and IR (information retrieval) as it is being developed in this system.

The largest CAI programs relating to the VIC system are on basic ophthalmology and glaucoma. At the present time the student must request these courses. Thesaurus code numbers have been assigned to frame sequences dealing with specific subjects. This code is the link between the data bank and program segments. For example, if the user wants to know about the technique of ophthalmoscopy, the frames of the basic ophthalmology course which explain ophthalmoscopy will then be presented to him if he signs on for CAI and enters that term. In this way the user can readily receive both instruction and a bibliography on the subject he has selected from the thesaurus.

Several users from remote locations have used the VIC system and residents in ophthalmology have taken the CAI courses. The system appears to be effective in principle and it is being developed further to improve the techniques and to expand the data base.

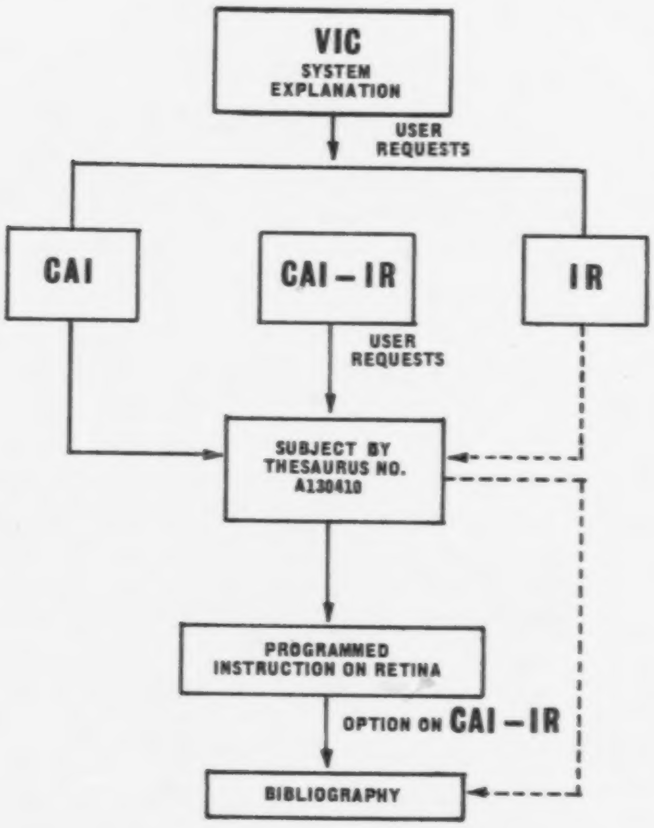
VIC
SYSTEM EXPLANATION
USER REQUESTS
CAI
CAI – IR
IR
USER REQUESTS
SUBJECT BY THESAURUS NO. A130410
PROGRAMMED INSTRUCTION ON RETINA
OPTION ON CAI – IR
BIBLIOGRAPHY

Figure 5. Design of the VIC computer-user interaction; following the system explanation, the user has the option of the selecting computer-assisted instruction (CAI), literature retrieval (IR), or a combination of both (CAI-IR).

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CAI in Hematology

In the case of CLOT, an instructional program in hematology, CAI is used to simulate a clinical experience. This program was developed by Dr. Daniel Deykin and Miss Barbara Gilcrest, both of the Harvard Medical School. The following frames illustrate the strategy they are using to develop this course.

FRAME 1

```
Student:    s53/clot

Computer:   YOUR NAME IS STUDENT 53.
            HELLO. I AM THE JUNIOR INSTRUCTOR ON THE
            HEMATOLOGY STAFF. TO WHOM AM I SPEAKING
            PLEASE? TYPE IN YOUR LAST NAME, THEN
            PRESS EOB.

S:          smith

C:          AND YOUR FIRST NAME.

S:          john

C:          THANK YOU. I THINK, DOCTOR SMITH, WE
            SHOULD PLAN TO SPEND ABOUT 45 MINUTES
            TOGETHER. HAVE YOU READ THE PAGE OF
            PROGRAM INSTRUCTIONS AND YOUR NOTES FOR
            LECTURES XIII AND XIV?

S:          yes

C:          GOOD. THEN LET'S BEGIN!
```

An attempt at personalization has been made in the sign-on procedure. The student's name is stored in a buffer and used at different points in the program.

FRAME 2

```
Computer:   AT 11 P.M. ON CHRISTMAS DAY, A 23 YEAR OLD
            AGITATED, WEEPING NURSE IS BROUGHT TO THE
            EMERGENCY WARD WHERE YOU ARE ON DUTY.
            SHE IS BLEEDING FROM HER NOSE AND GUMS,
            AND HAS MULTIPLE ECCHYMOSES. HOW WOULD
            YOU PROCEED? USE THE KEYBOARD TO ENTER
            THE STEPS YOU FEEL SHOULD BE TAKEN FIRST.
            PLEASE USE ONLY WORDS FROM YOUR
            VOCABULARY LIST.
```

This frame presents a verbal description of a medical episode that defines a problem for the student. To make the task manageable at this point, the student is given a list of terms to use in making his responses. In this way his vocabulary is delineated and the processing simplified.

Frames 3, 4, and 5 show how the student is prompted to respond with information he has been taught but has not used in a clinical setting. The prompting techniques are being developed. Some also involve the use of discrimination techniques so that inaccurate or inappropriate responses are immediately identified by the system for the student, but this strategy has not been tested as yet.

FRAME 3

Computer:	PRESS EOB AFTER EACH CHOICE AND WAIT FOR THE GREEN PROCEED LIGHT BEFORE ENTERING ANOTHER. PRESS EOB ALONE TO END YOUR LIST.
Student:	detailed history
C:	CORRECT. ANYTHING ELSE? IF NOT, PRESS EOB.
S:	physical exam
C:	CORRECT. A DETAILED HISTORY AND PHYSICAL EXAM ARE ALWAYS FIRST IN EVALUATING A PATIENT. SPECIFICALLY, WHAT TYPE OF INFORMATION WOULD YOU WANT TO OBTAIN IN TAKING THIS GIRL'S HISTORY? CONSTRUCT PHRASES FROM THE VOCABULARY LIST. FOR EXAMPLE, "MOTHER'S MAIDEN NAME," IF THOSE WORDS APPEARED ON THE LIST. PRESS EOB AFTER EACH AND WAIT FOR MY COMMENT BEFORE ENTERING THE NEXT PHRASE. PRESS EOB ALONE TO TERMINATE THE LIST, AS BEFORE.

FRAME 4

Student:	previous response to trauma
Computer:	GOOD. AND?

S: joint bleeding

C: YES, THIS INFORMATION COULD BE OBTAINED IN THE HISTORY. WHAT ELSE?

S: drug history

C: CORRECT. IS THAT ALL?

S: family bleeding problems

C: NO, AT LEAST I NEVER PHRASED IT THAT WAY. TRY AGAIN.

S: hereditary bleeding disorders

C: VERY GOOD. CONTINUE.

FRAME 5

Student: dietary deficiency

Computer: VERY GOOD. CONTINUE.

S: previous illness

C: NO, SORRY. IF YOU ARE PRETTY SURE OF YOUR ANSWER, YOU SHOULD PARAPHRASE IT, HOWEVER. OTHERWISE ENTER SOMETHING ELSE.

S: location of skin bleeding

C: YES. WHAT ELSE?

S: location of joint bleeding

Review and clarification are introduced in Frame 6. There is a good deal of research to suggest that guided review is an effective procedure. The problem in the CAI setting is one of using it as effectively as possible. This is where the requirement for research to establish a rule becomes evident. We need to know the factors that go into the "if . . . then . . ." statement for the use of review. Similarly, we need to study the use of preview.

FRAME 6

Computer: YES. WHAT ELSE?

Student: I don't know

C: WE SEEM TO HAVE SOME COMMUNICATION PROBLEMS, AND I DON'T WANT TO INSIST ON SPECIFIC WORDING. FOR EFFICIENCY, ALLOW ME TO SUMMARIZE THE DESIRED INFORMATION.

1. ONSET OF SYMPTOMS
2. RESPONSE TO TRAUMA OR SURGERY
3. CHARACTERISTICS OF BLEEDING (PRIMARY OR SECONDARY)
4. OTHER ILLNESS (e.g.: RENAL OR LIVER DISEASE, CANCER)
5. FAMILY HISTORY OF BLEEDING
6. DIETARY ABNORMALITIES
7. HISTORY OF DRUG INGESTION AND MEDICATIONS

Isolation is accomplished in this program in Frame 7 by asking the student what he would especially look for during the physical examination. Other techniques are used in CAI programs, e.g., underlining, capitalization, typing in red.

FRAME 7

Computer: WHAT WOULD YOU ESPECIALLY LOOK FOR DURING THE PHYSICAL EXAM? PROCEED AS BEFORE.

Student: location of all bleeding areas

C: YES, THIS INFORMATION IS IMPORTANT.

S: malnutrition

C: GOOD. NO ONE MENTIONS THIS.

S: malignancy

C: GOOD. NO ONE MENTIONS THIS.

S:	bruise
C:	GOOD. NO ONE MENTIONS THIS.

Note, in Frame 8, that reliance is occasionally placed upon the request for paraphrasing of responses. This is a middle position between saying right or wrong. It is employed while we accumulate data from students that can then be used to make the system better able to act as if it understood the student. This ability to constantly and immediately update the program is not to be underestimated. Also involved is student authorship. The responses the system collects provide data for use by the author in modifying the program. Student feedback to the author is necessary; it is one way to upgrade the system.

FRAME 8

Student:	jaundice
Computer:	YES, AS A SIGN OF OTHER ILLNESS. AND?
S:	deformity
C:	NO, AT LEAST I NEVER PHRASED IT THAT WAY. TRY AGAIN.
S:	petechiae
C:	GOOD. NO ONE MENTIONS THIS.
S:	pulse
C:	YES, THIS COULD INDICATE A MAJOR BLOOD LOSS.
S:	blood pressure
C:	YES, THIS COULD INDICATE A MAJOR BLOOD LOSS.
S:	evidence of previous surgery
C:	NO, SORRY. IF YOU ARE PRETTY SURE OF YOUR

ANSWER, YOU SHOULD PARAPHRASE IT, HOWEVER. OTHERWISE ENTER SOMETHING ELSE.

Another use of review is illustrated in Frame 9. Frames 10-14 illustrate the program and Frame 15 shows the summary given to each student.

FRAME 9

Computer: YOU WILL PROBABLY DO WELL IN THE CLINIC. HOWEVER, LET ME JUST SUMMARIZE WHAT ONE SHOULD LOOK FOR DURING THE PHYSICAL EXAM.

1. LOCATION OF BLEEDING (SKIN, JOINTS)
2. JOINT DEFORMITY
3. OTHER ILLNESS (e.g., UREMIA, CANCER)
4. EVIDENCE OF MALNUTRITION

UNFORTUNATELY THE NURSE WAS TOO AGITATED TO GIVE A MEANINGFUL HISTORY, BUT HER ROOMMATE SAID THE PATIENT HAD NEVER BLED BEFORE AND SHE KNEW OF NO FAMILY HISTORY OF BLEEDING. SHE ALSO SAID THE PATIENT HAD BEEN UNUSUALLY DEPRESSED DURING THE PREVIOUS WEEK. WHAT SCREENING LABORATORY TESTS SHOULD BE DONE? FOR CONVENIENCE, ENTER THE CORRESPONDING LETTERS (A-M), LEAVING A SPACE BETWEEN ENTRIES.

FRAME 10

Computer: WHICH STAGE OF THE CLOTTING SEQUENCE DOES THE THROMBIN TIME TEST? (FIRST, SECOND, THIRD)

Student: third

C: CORRECT. IN THIS CASE THE THROMBIN TIME IS NORMAL, IMPLYING FIBRINOGEN CONVERSION IS INTACT. THE GIRL HAS NO PAST HISTORY OF BLEEDING, NOR IS THERE A FAMILY HISTORY OF BLEEDING. UNDER SUCH CIRCUMSTANCES, HER SEVERE BLEEDING SUGGESTS AN ACQUIRED

	DEFECT. WHAT KINDS OF ACQUIRED BLEEDING DEFECTS ARE CONSISTENT WITH THIS CLINICAL PICTURE? ENTER YOUR CHOICES ONE AT A TIME. PRESS EOB AFTER EACH AND WAIT FOR THE PROCEED LIGHT BEFORE ENTERING THE NEXT. PRESS THE EOB KEY ALONE TO TERMINATE YOUR LIST.
S:	drug

FRAME 11

Computer:	CAN YOU GIVE ME AN EXAMPLE?
Student:	aminocaproic acid
C:	"AMINOCAPROIC ACID" IS NOT ON MY LIST OF CORRECT ANSWERS. YOU MAY HAVE MISSPELLED SOMETHING, USED A WORD NOT IN MY VOCABULARY, OR MADE A MISTAKE. TRY AGAIN.
S:	coumarin
C:	YES, COUMARIN OR WARFARIN (THE GENERIC NAME) CAN CAUSE A BLEEDING DEFECT.

FRAME 12

Computer: I FEEL I MUST URGE YOU TO BE MORE COMPREHENSIVE IN YOUR APPROACH TO SUCH QUESTIONS. FOR NOW: LET ME GIVE YOU A CHECK LIST OF ACQUIRED BLEEDING SYNDROMES WHICH MUST BE CONSIDERED. NOT ALL PERTAIN TO YOUR PATIENT, OF COURSE.

1. ACQUIRED INHIBITOR OF BLOOD CLOTTING
2. HEPATIC DYSFUNCTION
3. INGESTION OF AN ANTICOAGULANT DRUG
4. DISSEMINATED INTRAVASCULAR COAGULATION (i.e., CONSUMPTION OF COAGULATION FACTORS)
5. FIBRINOLYSIS
6. DILUTION OF COAGULATION FACTORS (AS WITH MORE THAN 8 UNITS OF STORED BANK BLOOD)

7. RENAL DISEASE (UREMIA)
8. IDIOSYNCRATIC DRUG REACTION (APLASTIC ANEMIA, THROMBOCYTOPENIA)

I WOULD LIKE TO STRESS THAT SUCH ACQUIRED DEFECTS ARE USUALLY MULTIPLE AND HAVE AN ACUTE ONSET, BUT MAY BECOME CHRONIC. DISSEMINATED INTRAVASCULAR COAGULATION (4) WOULD BE UNLIKELY IN THE FACE OF A NORMAL PLATELET COUNT, HOWEVER.

FRAME 13

Computer: NEXT WE MUST DISTINGUISH AMONG THE ABOVE POSSIBILITES. WHICH DISORDER WOULD BE EITHER DIAGNOSED OR ELIMINATED BY MIXING A SMALL AMOUNT OF THE PATIENT'S BLOOD WITH A LARGER VOLUME OF NORMAL BLOOD IN COAGULATION TESTS?

Student: acquired inhibitor of blood clotting

C: VERY GOOD.

FRAME 14

Computer: WHAT WOULD YOU LIKE TO SEE HAPPEN TO THIS PART OF THE HEMATOLOGY COURSE IN THE FUTURE?

1. CONTINUE COMPUTER TEACHING, INCREASING THE NUMBER OF PROBLEMS ON CLOTTING DISORDERS AND/OR INCLUDING PROBLEMS ON OTHER COURSE MATERIAL.
2. CONTINUE COMPUTER TEACHING, KEEPING THE NUMBER OF PROBLEMS CONSTANT.
3. DISCONTINUE COMPUTER TEACHING.
4. NOT SURE.

Student: 1

C: DID THE PROGRAM FORMAT ITSELF HINDER YOUR LEARNING?

1. NO
2. YES
3. NOT SURE

```
S:          3

C:          THANK YOU, JOHN SMITH.
```

FRAME 15

```
Computer:   WOULD YOU LIKE TO SEE HOW YOUR
            PERFORMANCE HAS BEEN RECORDED FOR THIS
            SESSION? IT WAS DONE FOR PROGRAM
            EVALUATION, NOT FOR GRADING PURPOSES.

Student:    yes

C:          ALL RIGHT.

            CORRECT             7
            WRONG              14
            I DON'T KNOW        1

            TIME SPENT WAS 60 MINUTES.
            PLEASE TAKE THE TYPEWRITER OUTPUT
            WITH YOU SO THERE WILL BE NO SAMPLE FOR
            STUDENTS IN THE FOLLOWING SESSIONS. NOW
            TYPE "SIGN OFF."

S:          sign off

C:          LINE IS SIGNED OFF
```

This program was used for the first time this semester. Data on student performance, when analyzed, will be used mainly to improve the program. This type of program provides the student with the opportunity to make the transition from the basic sciences to the clinical use of information. The transfer of learning problems that are involved in this conversion of information is a critical phase of dental and medical school experience which has received too little attention and offers much promise.

TRANSFER RESEARCH

Psychologically, the area of transfer of learning is very important. There are many findings from transfer studies that provide useful do's and don't's for the programmer. We plan to examine these and to put many of them to the test within instructional programs in the health sciences.

For example, one phenomenon of interest is proactive interference. This is a phenomenon that relates to the effects of early learning upon the subsequent learning and retention of similar material. The results of research indicate that earlier-learned material that is similar to newly-learned material interferes with the retention of the newly-learned information. It also has been shown that overlearning can reduce interference. The question is whether it is possible to develop some rules for use with CAI to raise the student's level of mastery to the point where this kind of interference is minimized. The rationale for this approach comes primarily from many separate studies conducted in the laboratory. Consequently our research would provide an integration of knowledge in the field of learning as well as relate to a practical problem of instruction. Such concepts as proactive interference, learning how to learn, and overlearning all need to be studied and related to the problem of developing instructional strategies.

SUMMARY

The needs of dentistry and the health sciences in general suggest that educational technology could be of great practical value. The work accomplished thus far at different CAI laboratories on problems of instruction is encouraging. While the experience to date is limited, the concepts and approaches seem to fit current needs and to provide an effective solution which the students probably like more than the faculty. The accomplishments to date have been modest and were not easily achieved. Nevertheless, the results are sufficiently positive in terms of student performance to suggest that there is considerable promise in this approach, not only for its contribution to interactive instruction but also for its contribution as a catalyst to all forms of instruction in a dental and medical school environment.

It is apparent that the form and operation of educational programs in the health sciences are going to be considerably changed over the next few years; instruction will become more individualized and interactive. It would seem that computer-aided instruction could make a substantial, positive contribution to this kind of change. Hopefully, present economic constraints will not impact too severely on the further development of what appears to be a promising set of new solutions and developments.

RALPH E. GRUBB is a Research Psychologist with IBM Education Research, San Jose, California and is also Visiting Lecturer at Stanford University. He holds his B.S. from King's College and his M.S. in Psychology from the University of Delaware. At the Thomas J. Watson Research Center, Yorktown Heights, New York, he was a founding member of IBM's original computer-assisted instruction project where he authored a computer-assisted instruction course in statistics. He also co-authored the COURSEWRITER language for which he received an IBM achievement award. His current work in computer-assisted instruction at IBM, San Jose, is heavily involved with development of the "learner-controlled" approach.

CAI: TECHNICAL ASPECTS AND RESOURCES

Ralph E. Grubb, IBM Education Research
San Jose, California

COMING TO TERMS WITH CAI

In order to put into perspective the field of computer-assisted instruction (CAI) and its environs, consider the following definitions.* *Technology* is the systematic application of organized scientific knowledge to practical tasks. Technology, in these terms, is in no way equated with hardware. Rather, technology in this sense is synonymous with the well-known term "applied science."

Of all the practical tasks that could concern us, the scope of this discussion is limited to education. Therefore, *Educational Technology* is the application of technology to education.

While many areas of education interest me, the area of instruction draws my greatest attention. The following definition recognizes that there are only four possible components in any instructional setting: students, subject matter, materials and teachers—the student being the only one necessary for learning. *Instructional Technology* is the use of *technology* to improve the student's interaction with his subject matter, materials and teachers. This definition assumes that unless the interaction is improved it is not worthy of the title.

In order to define CAI, the only word substitutions necessary are "CAI" and "computer" to form the definition: *CAI* is the use of a *computer* to improve the student's interaction with his subject matter, materials and teachers. This definition should lay to rest the question whether good teachers will be displaced by CAI.

---

*Formulated, in private discussion, by P.M. Beatts, IBM Education Research, San Jose, California.

It is appropriate to ask, "In what ways *can* a student interact with his subject matter, materials and teachers?" The following list of eleven "modes of interaction" is offered as a working basis for this discussion and can be, I think, a helpful guide for planning and evaluation.

1. drill
2. practice
3. problem review
4. diagnosis and prescription
5. tutorial
6. gaming
7. simulation
8. factfinding
9. computation
10. logical problem solving
11. exploration

This list also provides an operational test for defining the term "computer-managed instruction" (CMI). If diagnosis and prescription are involved in the course, is the instruction itself contained in the computer program? If the answer is yes, then the course is CAI; if no, then it is CMI.

While space will not permit discussion of each of the above, I would like to define several terms in order to show the different requirements imposed on instructional systems. *Drill,* for example, is the formation of correct habits under routinized conditions while *practice* implies an accustomizing or the acquiring of proficiency under a wide variety of conditions. At the other end of the list, *exploration* is characterized on the part of the student by an inquiring or "what if?" attitude. This leads to the conclusion that, under conditions of exploration, one must grant to the learner a great deal of freedom to probe freely in a subject matter.

The requirements for CAI at this level, including course organization, terminals and operating systems, resemble those of information retrieval systems rather than those previously associated with teaching machines. It should also be pointed out that these eleven interaction types are not mutually exclusive; that is, one could combine a number of these types to form dynamic courses. What was previously considered elementary in CAI, i.e., *practice,* now takes on a very different appearance under these conditions. Consider the following examples of experimental work being conducted at the IBM Education Research Department at San Jose, California.

PUTTING THE TERMS TO WORK

Learner-controlled Statistics

Ralph Grubb and Tom Weik

This course segment of two chapters (Measures of Central Tendency and Measures of Dispersion) represents an attempt to combine certain qualities of exploration with those of tutoring, computation, and simulation, into a series of maps. Thus, the student can chart his own path through introductory statistics. The reasons for putting the learner rather than the program in control are the scarcity of authors who know how to write courses that recognize individual differences adequately; the wide differences in students' background and motivation; and the need for making students responsible for their own actions.

The current investigation is being carried out on an IBM 1500 instructional system which was designed for research and development in CAI.

The system consists of an IBM 1800 central processor with disk cartridges for active course files and the system monitor, tape units for bulk storage of curriculum and student records, a station controller and video buffer, and the following input-output (I/O) units: typewriter, cathode ray tube (CRT), keyboard, light pen, image projector and an audio response unit.

The course segments reported here use only the CRT, keyboard, and light pen as I/O devices.

The system monitor utilizes an author entry language known as Coursewriter II. This language permits subject matter experts who are naive concerning computers to construct their courses under a variety of teaching techniques. Later in this discussion I will have more to say regarding developments in the area of author languages.

Method. When a student registers for this course via the CRT terminal, the first display he encounters is a map of the statistics course with appropriate directions for its use.

The map consists of a series of boxes, connected in various ways, and inscribed with topics or concepts that the student can access in order to route his way through the course. To do this, the student points his light pen at the area of the map that interests him. Immediately, his screen is erased and he is confronted with a more detailed map of that subsection of the course. Similarly, as he makes successive choices with the light pen he proceeds deeper into successive levels of the course. At the lower levels of the structure he may enter on the keyboard constructed responses to questions or problems posed through the computer. If he chooses, he can also point his light pen at any time to one of several target areas to the side of the screen that will return him to the previous map, main map, or a glossary.

In addition, there are usually other target functions represented on the screen which will transfer the student laterally to a number of related topics in the course. This would suggest that the "map" approach is more analogous to a network than

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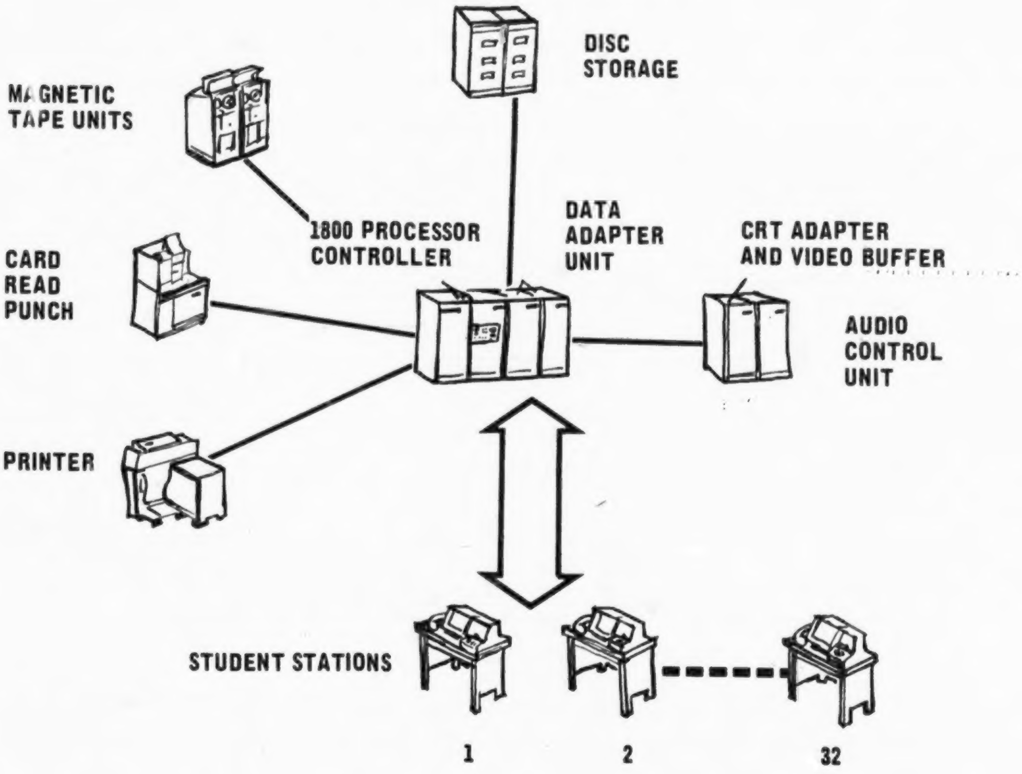
DISC STORAGE
MAGNETIC TAPE UNITS
1800 PROCESSOR CONTROLLER
DATA ADAPTER UNIT
CRT ADAPTER AND VIDEO BUFFER
CARD READ PUNCH
AUDIO CONTROL UNIT
PRINTER
STUDENT STATIONS
1
2
32

Figure 1. IBM 1500 instructional system.

□□□

a simple decision tree. In the latter, the student would have to back up the tree to some prior starting point in order to come down a new path, thereby vitiating the flexibility of this course. In the learner-controlled approach there is neither a common starting nor ending point.

In sum, the student taking *this* course soon realizes that he is like a man using a motion picture camera equipped with zoom, pan and tilt features. Successive states of magnification of the subject expose more and more detail while panning and tilting keep the structure and perspective intact at all times. Symbols attached to each map inform the student of the level of "magnification."

Results. In order to test the effectiveness of this approach an experiment was designed to measure this learner-controlled approach against four other experimental conditions of student control or the lack thereof. This was accomplished by copying the learner-controlled statistics course onto another disk cartridge and deleting all the maps and branch options open to the student. In this way a linear statistics course was created which was identical in course content with the original version. From these two conditions, learner-control (LC) and linear (L), five experimental conditions were created, which are summarized in Table I.

Table I

Experimental Design

Condition	*Chapter 1*	*Chapter 2*
LC - L (n = 10)	Learner Control (LC)	Linear (L)
LC - LC	LC	LC
L - L	L	L
L - LC	L	LC
LC*	LC	

*This condition differs from the LC - LC condition in that chapter sequence is not a restriction.

Fifty IBM students served as subjects in this study and were divided equally among the five experimental conditions. The analysis of variance model indicated a reliable difference ($P < .05$) between treatments. Tests between individual treatments were made with the result that if students drawn from the subject population are given the unique freedom (LC condition) to construct a pathway through a segment of elementary statistics, on the average they will score higher on the post-test than their counterparts under other treatments, save the LC-LC condition. In the latter condition, the student learns under conditions of learner-control but takes chapters in sequence.

These results are evidenced in a regression plot as shown in Figure 2. The abscissa shows the pretest score (X) for students while the ordinate shows post-test performance (Y). The lines shown are ones of best fit for each treatment group and are found by a least squares criterion.

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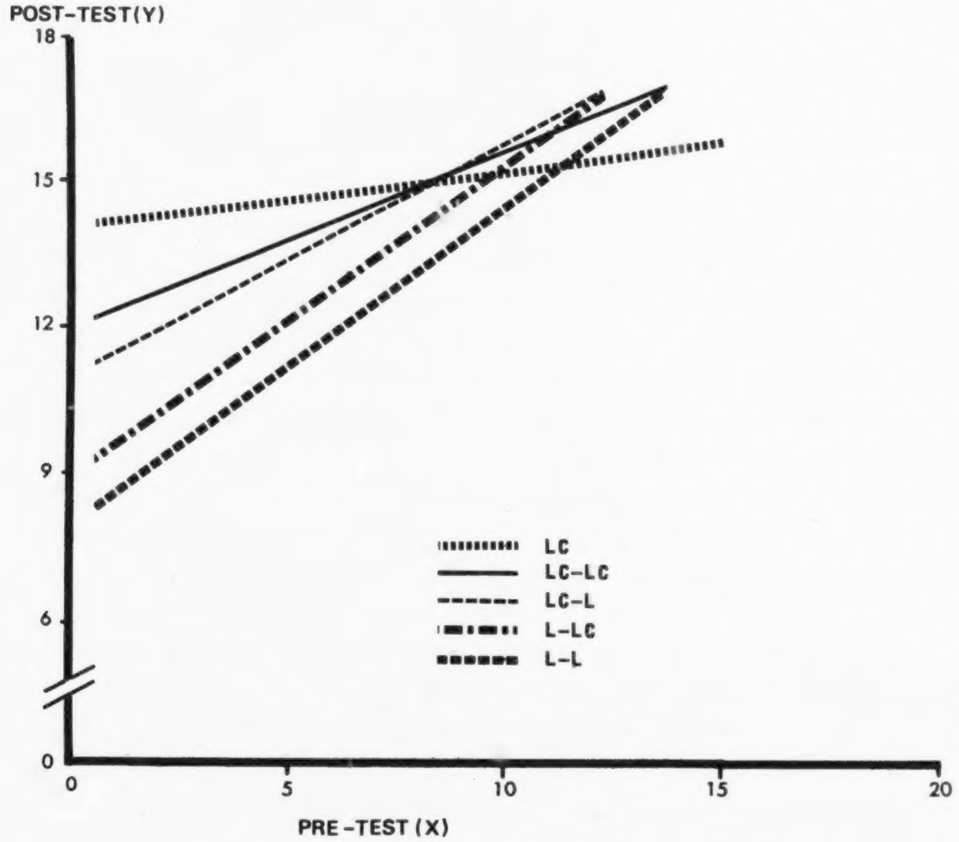

Figure 2. Regression of post-test score on pre-test score for five experimental conditions.

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This plot tends to reveal that complete learner-control, within the study parameters, on the average produced uniformly high performance over the entire range of pretest performance.

Learning acquired under conditions of anything less than learner-control, for this study, produced post-test performance that was more heavily dependent on pretest performance.

A CAI Arithmetic Practice Program

Peter Dean and Suzanne Sax

Numerical skill has been the subject of many CAI projects, including the first CAI program written in 1958.

Most of these CAI programs can be characterized as a program-controlled algorithm that generates randomly, or otherwise, a series of problems for "flash card" presentation to the student. Little or no remediation is offered, and, if available, is for a prototype problem or class of problems.

Method. The present CAI program was designed to provide elementary school children with number practice problems (addition, subtraction, and multiplication) in which they had the option of: constructing their own problems, requesting the machine to generate them by means of modified random number generators, asking the machine to present problems written by the author, and seeking specific remediation on problems under any of the above conditions.

The first three options above are labelled "instructional algorithm" in Figure 3. The program is written as a series of subroutines so that the output of one is input to the next routine.

Assuming that the student has decided he will make up his own problem, the "problem description" routine permits the student to describe his problem in rather free-form fashion.

The "problem generator" then presents the problem to the student in horizontal or vertical format with the appropriate arithmetic operator inserted.

The student's answer is then checked for correctness by another subroutine.

If he asks for help, a "specific remediation" routine is called from a library which proceeds to break down the troublesome problem in a step-by-step manner accompanied by English instructions at each step. If the student is still wrong in the specific remediation routine, he could be branched to a true drill program on basic number facts.

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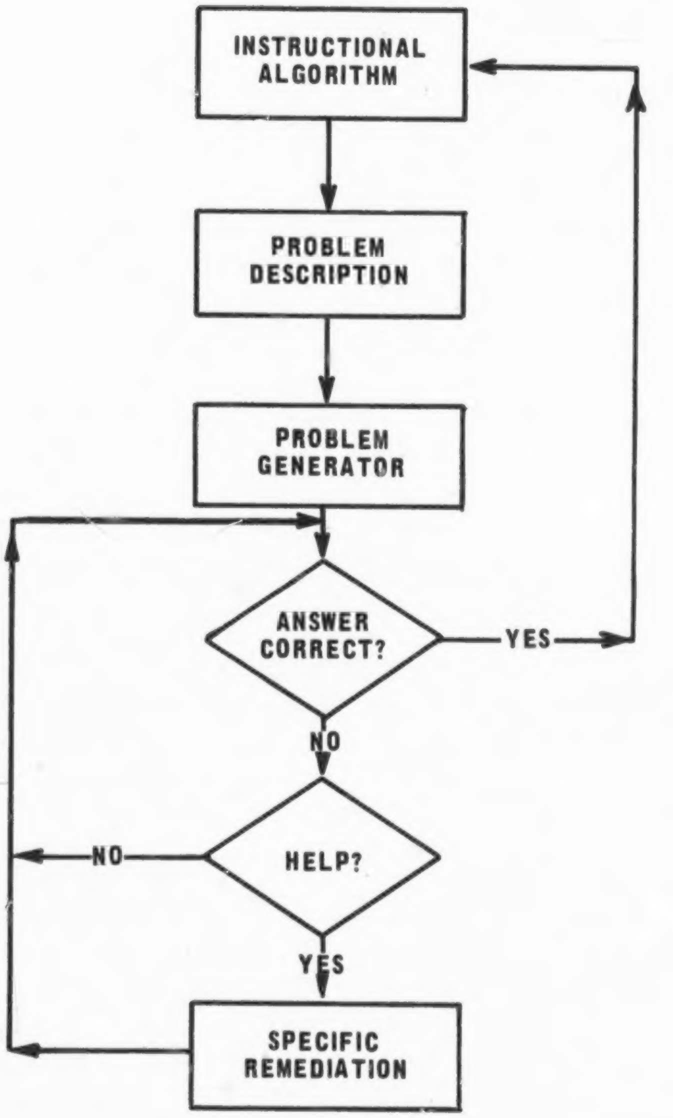

INSTRUCTIONAL ALGORITHM
PROBLEM DESCRIPTION
PROBLEM GENERATOR
ANSWER CORRECT?
YES
NO
HELP?
NO
YES
SPECIFIC REMEDIATION

Figure 5. Flow chart of arithmetic practice program.

□□□

The following portions of a student's interaction are listed below:

(computer) Type a 3 digit number.

(student) 478

```
(c)         Type a 2 digit number.

(s)              39

(c)             478
                x39
              ------
(s)            6632

(c)         Nooooo! If you wish to try the problem again press
            space bar. If you want me to show you how to do
            the problem, type "h".

(s)               h

(c)         Multiply the units digit on top, 8, by the units digit
            of the multiplier, 9.

                478
                x 9
              ------
(s)               2

(c)         Multiply the next digit on top, 7, by the units digit
            of the multiplier, 9, and add the tens digit, 7, to
            the product.

                7
                478
                x 9
              ------
(s)              02
 .
 .
 .
(c)         Move the tens partial product one place value to
            the left and sum the partial products.

                4302
              +1434
              ------
(s)            18642

(c)         And you have solved the problem!
```

Results. Experimental results from 120 grade school children on an earlier version of this course (lacking the specific remediation feature) suggested that merely giving control to the student did not produce significant group post-test gains, compared with linear controls. Rather, specific remediation is also needed and is now added to the course as illustrated above. The results from this additional feature are not yet known.

One finding from the study disclosed that the use of learner-control with 6th graders resulted in significant savings in practice time.

Decomposition of Numbers into Primes

Pat Beatts

This program segment was written in a tutorial mode to give instruction in breaking down numbers into primes. Note the following free interchange between this student and the computer:

(c)	O.K., to clarify the rules for decomposition by the first method, you must answer 5 questions. Ready? Hit the spacebar.
	1. What do we divide by first?
(s)	2
(c)	2. When do we stop dividing by this?
(s)	When we get to 39
(c)	Are you sure you are ready to do this? Anyway try once more.
(s)	When the product will no longer divide by 2
(c)	Fine
	3. What do we divide by next?
(s)	3
(c)	4. When do we stop dividing by this?
(s)	When 3 will no longer go into it
(c)	Good! One last question.

5. When do we stop trying to divide any further?

(s) When we have all prime numbers

(c) Now that you've finished, let's look at the whole of the 5 questions and the correct answers all together.

Introduction to Computing

Suzanne Sax, Ralph Grubb and Peter Dean

How a computer works remains a great mystery to many people, including large numbers of employees in the computing industry. Various attempts to remedy this have included classroom exercises which make elaborate use of magnetic chalk board displays, students serving as signaler, accumulator, etc. While each method has had some degree of success, none, I think, has the promise found in the present CAI approach.

In this program a student can type on his keyboard a simple arithmetic expression of his choice. This can be as simple as 2 + 3 or more advanced, as (((24 ÷ 3) x 5) + 4). Rather than providing a direct numeric answer, this program translates the expression into English and assembles it into a quasi-flowchart form for display on the CRT (see Figure 4).

At this point in the process the student has already been introduced, perhaps without his awareness, to several levels of coding inherent in computing. The student now has the option of seeing a mini-computer execute the results.

This simulated computer's internals include: thirty locations of storage, an I/E time indicator, instruction counter, address register, data register, instruction register and accumulator—all of which are displayed on the student's CRT. With the original arithmetic expression still in view, he now sees his data as entries in storage locations in addition to seeing a program that has been built to execute the problem. The program instruction set is composed of System/360 mnemonics, i.e., l = load, a = add, d = divide, etc., (see Figure 5).

The student can now execute the program in a single-step mode, if he wishes, by repeatedly pressing the space bar on his terminal and observing the data flow within the simulated computer.

□ □ □

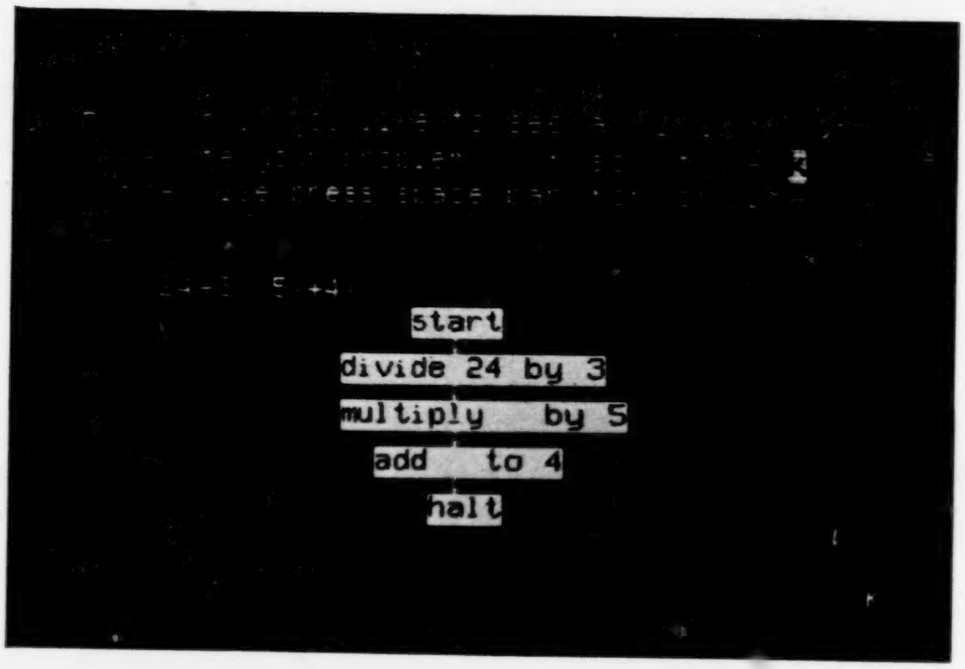


Figure 4. CRT display of program steps necessary to evaluate a specific arithmetic expression.

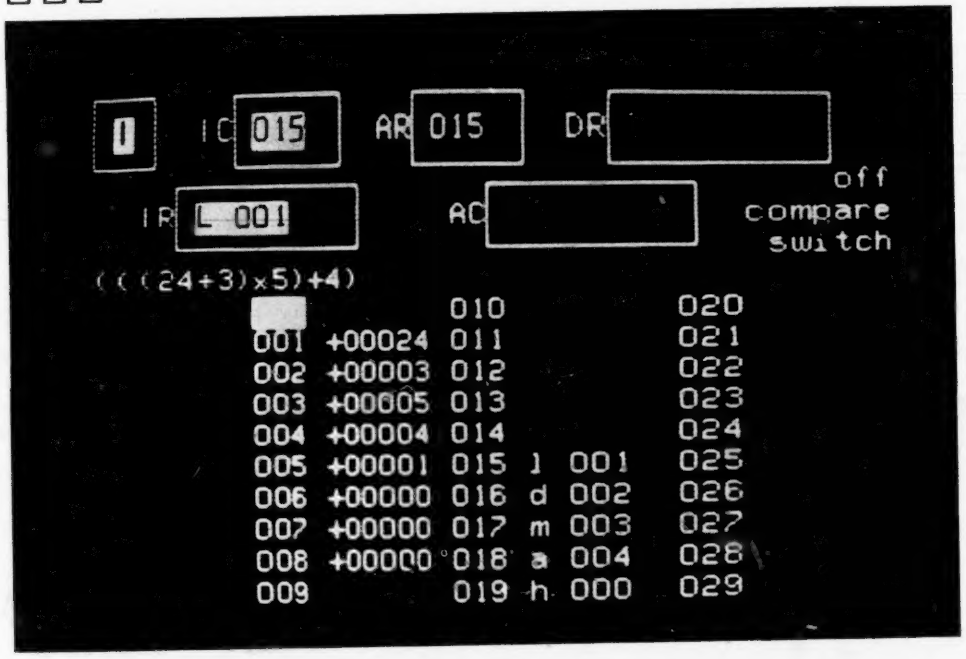
□ □ □

At any point he can branch out of the procedure to: participate in the register displays by filling in the expected contents from keyboard responses; go back to the flow chart segment and construct another arithmetic expression; or write a program of his own and have it executed!

RESOURCES NEEDED

Without going into any great detail, let me quickly list the resources needed at this time if a CAI effort is to be successful. Regardless of the size of a research and development project in CAI, certain functional skills are required. These skills are generally the result of backgrounds in educational psychology, experimental design and statistics, author-teacher experience, instructional programming, instructional coding, familiarity with computer assembly languages, cardpunch operation, computer operation, administrative co-ordination, supervision and support, in addition to teaching—and learning from—students.

In rare instances, a small group of people may possess all these functional characteristics. Usually a larger team is needed



```
 I    IC 015      AR 015      DR
                                               off
      IR L 001           AC                compare
                                            switch
(((24+3)x5)+4)
                          010                 020
          001  +00024     011                 021
          002  +00003     012                 022
          003  +00005     013                 023
          004  +00004     014                 024
          005  +00001     015  l  001         025
          006  +00000     016  d  002         026
          007  +00000     017  m  003         027
          008  +00000     018  a  004         028
          009             019  h  000         029
```

Figure 5. CRT display of simulated mini-computer executing the program steps shown in Figure 4.

in order to put the project on a reasonably large enough scale to meet realistic time schedules and make efficient use of the system. This would tend to indicate that, when a project of such scope is launched, the size of staff should be adequate to handle a "stable" of several subject-matter experts. In this way, full use of all talents and the hardware is most likely.

This leads to the inescapable conclusion that, with a large computer system and the time and talents of diverse experts, the originator of the course-content must have sufficient ability, talent, and expertise in his field to warrant the expenditure of time and effort. The pay-off is the wide adoption of the finished CAI course.

TRENDS

A decade of CAI experience lies behind us. It is timely and appropriate to look for substance. What have we learned? What trends in CAI are emerging? What is needed at this time in terms of resources?

It will be remembered that CAI is the use of a computer to improve the student's interaction with his subject matter, materials and teachers. The following views, entirely personal, will be tied to that definition by identifying trends and needs with such concerns as the student, modes of interaction, subject matter, materials, and teachers. The list will be suggestive rather than exhaustive.

The student. From the illustrations in this discussion and elsewhere, I predict a greater emphasis will be placed on learner-control in CAI. In addition to the cursory arguments mentioned earlier, researchers will find that the students' audit trails through the subject matter, as supplied by the computer, will be invaluable in discovering the nature of what is now referred to as "cognitive styles."

New developments in natural language processing in Coursewriter will also permit the student far greater freedom to interrogate data bases in CAI.

Modes of interaction. Because learners will assume more control in CAI programs, there will be greater utilization of such techniques as exploration, gaming, simulation, etc.

Subject matter. Granting more freedom to learners, coupled with natural language facilities, will cause narrow course boundaries to drop away; narrowly delimited courses will be replaced by a broad content area or knowledge space whose dimensionality will be found in the process.

Materials. The increasing use of multiple modes of interaction will suggest greater use of materials resource centers in contrast to building an entire course on a programmed text or CAI terminal. This in turn raises such questions as, "What objectives might best be met by the student, the instructor, library, laboratory, text, teaching machine, computer, etc.?" That is to say, education has been, and should continue to be, a series of experiences, both direct and mediated.

If the earlier predictions are realized, CAI terminals will need to be richer. Graphic displays, light probes and other associated audiovisual components will be needed if one is to do more than automate programmed texts.

The teacher. We know by definition that the teacher will be an integral part of CAI; however, studies conducted with programmed instruction have shown that it requires *better* teachers to teach in a context of automated instruction. This is understandable when one considers the larger role the teacher plays, which includes offering special help to students, each at a different place in a program. Furthermore, CAI is still a foreign and specialized topic to many educators. These factors suggest that training centers must be established in order to prepare teachers for these functions.

The author languages used for CAI courses also deserve attention since they still bear close resemblance to computer coding languages.

A recent development by Peter Dean, Ralph Grubb and Mike Dowsey has resulted in a course planning form and a computer preprocessor program that makes for a simplified author entry system which is machine and language independent, self-documenting, faster, and requires less author training than previous systems for many types of CAI authoring.

Since the major cost of CAI lies in program preparation, developments in this area could greatly influence the economics of CAI and ultimately its acceptance.

A final comment I might make with respect to the learner-controlled or exploratory mode of CAI is that despite the advances here described and currently underway, it will require continuing research to evaluate this new approach as a means of permitting unique freedom of exploration to any student within a subject. It seems likely that some other subject, less rigorously constructed than statistics, might be a better vehicle for evaluating the exploratory mode. In this connection, we might speculate on the possibilities inherent in a course such as English Restoration Poetry, or the Development of the English Novel. If this suggestion seems farfetched, consider the following quotation.

> The owner of this magic desk will, in fact, have at his disposal in compact form what would nowadays be the whole contents of a colossal reference library of millions of volumes. Moreover, by a system of indexing and automatic cross-reference, based on electronic selection, he will be able to extract what he needs by pressing a few keys, instead of going through the long process that is now necessary in public libraries.*

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*Earl Mountbatten, President of the British Computer Society, in his presidential speech to the Institute of Electronic and Radio Engineers, 1946.

JOHN A. STARKWEATHER is Director, Office of Information Systems, and Professor of Medical Psychology at the University of California, San Francisco Medical Center. He holds the A.B. degree from Yale University, and the M.A. and Ph.D. degrees in Psychology from Northwestern University. He has directed the activities of the Computer Center at the University of California San Francisco Medical Center since 1964. He has done extensive research in the analysis of verbal behavior, including the use of computers for natural language processing, particularly in the setting of the medical interview. This work has resulted in the development of two computer-assisted instruction author languages, COMPUTEST and PILOT. Dr. Starkweather serves as consultant to several federal and state governmental agencies and was a member of the Board of Trustees of EDUCOM from 1965 to 1967.

EDUCATIONAL NETWORKS AND INTERFACING WITH THE UNIVERSITY COMPUTING CENTER

John A. Starkweather
University of California
San Francisco Medical Center

In spite of my title on the program, I do not have a great deal to say about networks except as they relate to a broad concept of sharing facilities which is one means of maximizing our future efforts. What I will try to do is, first, give you an idea—particularly those of you who have not had the pleasure or pain of dealing with it—of what you might expect from the usual University Computing Center; second, say something about special computing needs as I have seen them in a medical center; third, discuss the possibilities of sharing facilities and skills within a campus, as well as similar sharing between separate schools; fourth, make some remarks on the development of computer aids to learning, and give examples of same application areas for conversational use of the computer with relevance to professional education; and finally, show where some improved man-machine communication methods can take us. That is probably enough for a day or two, but I will try to do something with that list in the next hour.

FUNCTIONS OF A UNIVERSITY COMPUTING CENTER

Now, how can you make use of a University Computing Center and avoid being trapped, like I was, into running it?

More and more, it seems possible that such centers may become versatile enough so that you may not have to. This did not seem true to me when I originally became involved and, as I say, it may be considered a kind of trap, which I think most of you should work hard to avoid.

Most academic computer centers have grown to fill not only their original scientific needs but also to provide computing services to research investigators who themselves have skills in mathematical or statistical analysis. The needs of administrative data processing have almost always been considered as separate problems and facilities for meeting such needs have developed independently. It is still true that the requirements of these two areas are quite different and that the backgrounds and methods of programmers who work on these different kinds of tasks have completely different life-styles.

In the setting of medical education, however, there is joint use of and joint concern with patient records required for the basic purposes of the institution which must also serve the needs of patient care and instruction of students in clinical and related matters. Interest in patient records is shared by administrators and managers concerned with the operation of the hospital, by instructors and students who are studying the clinical material, and also by research investigators who would like to make a different use of the clinical data. The daily operational concerns of those involved in these three factions of a university medical center are quite different and one can hear many predictions of failure when attempts are made to integrate services for them. The scheduling demands are different, as are the needs for different facilities and different kinds of supporting staff.

Some of the special needs of a medical computing center as against a general university campus computing center are a result of this close relationship between administrative activities and instructional and research activities. We somehow have to take care of the business aspects of running a hospital and the clinics. We have to build methods of handling patient record information. We need data acquisition and control of other interconnected apparatus, such as auto-analysers in the clinical laboratory, and things of this kind.

We have other administrative needs which may differ from a general campus. Operations within a medical library are usually quite different from those on a general campus. For example, there is a much heavier demand for serials and periodicals in the total operation than is usual elsewhere. Concerns about admissions to professional schools and student information in general are likely to be quite different. The scheduling of very high-cost facilities for interlocking kinds of professional curricula also introduces different concerns.

It might be of some interest to give a brief listing of the kinds of administrative projects currently underway in our setting which give a hint of what areas have sufficient pressure on them to get attention first. Outside of the hospital, we have projects such as a registration subsystem of a student record system; a revision, completion and maintenance of a medical school admissions system; a contracts and grants accounting system; a library serials system; grounds and buildings project-control and inventory; an academic personnel system; a personnel skills-locator system for transfers and promotions in the personnel department; a courses and grades subsystem of the student records system; a space utilization system, and so on.

Within the hospital itself, we have an equally demanding list of projects including modifications of the hospital business systems which, with all the interacting insurance plans, Medicare, and things of this sort, get to be very complex operations. In our hospital, for example, approximately six thousand bills need to be sent out each month. The system has projected into three separate phases with a great deal of detailed planning in each one.

Further projects involve the development of a clinical laboratory test-result reporting system; development of a medical records index, which is just the very first pass at the medical records—in an attempt to help people locate charts; and a revised census and bed-control system, so that people know in a timely fashion which beds are available and which patients are in which beds.

Let me just mention once again some of the possible advantages of integrated operation between these kinds of concerns—research and instructional concerns—which may somewhat offset the difficulty of trying to run these things jointly. There is a possibility of sharing file-access. I have already mentioned the kinds of overlapping files that might be possible. You could indeed make these people, with different points of view and different concerns, reasonable bedfellows. Further possibilities include sharing of staff skills and knowledge about what is available in a large computing facility; the sharing of programming systems;

and the possibility—which I heard a previous speaker mention—of a useful mix of instructional interactions and file-access, for example, where methods developed in one unit may very well have some application and usefulness for another.

One concern in the medical center which is very difficult to handle in a truly centralized fashion is data collection, control of apparatus, and control of experimental manipulations. Here I think the sensible route is the combining of local processors, which do this kind of immediate handling of data, and some linkage to a central computer that becomes useful either for a large analysis, large processing needs, or for access to the large central files.

An important but secondary advantage of combining local processors in one facility is that joint, and sometimes overlapping, justification for additions to the facility becomes possible. Some portion of the machinery, for example, may be justified by one program much more than by another, and yet the second program may very well benefit from that machinery having been installed. The management and administrative uses are the ones which push heavily in the direction of large, random-access file capacity. Although it might not be possible to justify such a huge capability for research or instructional purposes, it nevertheless becomes very useful to them to have that capability available. Instructional requirements may push very heavily for interactional use of the computer from remote points and this in turn may be especially useful, although not as easy to justify, for informational efforts of the administrative people, or the research people. There have been very few attempts to develop medical center systems which really try to handle this problem on a centralized bais. One of the few is the ACME system at Stanford which does not try to handle a lot of the administrative tasks that I have described to you, but which is relatively successful in centrally handling the data-acquisition control problem.

INSTRUCTIONAL FACILITIES — HARDWARE AND SOFTWARE

At the San Francisco Medical Center of the University of California, we have organized an office with divisions entitled Management Systems, Instructional Systems, Research Systems, and the Computer Service Facility. I do not think there is anything very remarkable about that because the activities of teaching, research and administration are the natural characteristics of university life.

I am no longer going to talk about either the mangement, administrative area or the research area, which I think you are probably well able to imagine and to find in one form or another at different places, but instead I will give you a little detail on the direction of development within the instructional division, since that is the major interest of this conference.

Our computer system is a mix of facilities which is partially justified in various ways by the needs of the separate portions of the operation. We have an IBM 360 Model 50 with 256,000 bytes of high-speed core, a million bytes of slower speed core, and a 2314 disk unit with eight drives at present and four more to be added this spring. We operate a system that provides two batch partitions of 140,000 bytes of storage each, which can be combined for large-size jobs by a simple control on the job card. Because of the large disk-storage capabilities, a wide range of library programs are accessible on call.

There is a remote job-entry access to these batch operations. One batch terminal, for example, with its own printer-reader, is located at a junior college about 50 miles from our center. Remote entry for batch work can also be accomplished via typewriter terminals, such as teletypes or 2741 terminals. We are operating four teleprocessing systems: CPS, which is an interactive subset of PL/I; APL, which is a mathematically oriented interactive programming language; and ATS, which is a kind of secretarial aid for storing, editing and retrieving text information. It is very useful for specifications and proposals which are changed in some degree from one typing to the next.

The fourth, teleprocessing system is an interactive conversational programming language called PILOT—Programmed Inquiry Learning Or Teaching—which is a system that we developed.* It has many similarities to other CAI author-languages, but we feel that it also has advantages over others.

The instructional division of this office that I have been describing has been working on this improved language for expressing conversational strategy. Until very recently, it has been centering most of its efforts on that project, and also on the

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*Starkweather, J.A., PILOT and the preparation of program-oriented medical records for computer-assisted learning. In L.M. Stolurow *et al.* (eds.) *Computer Assisted Instruction in the Health Professions*, Newburyport, Mass., Entelek, 1970.

production of brief demonstration programs for the purpose of discovering those professional faculty members in specific content areas who are both interested and excited about the potential of computer assistance to learning as applied to their specialty.

There is a need for this group to develop both marketing and consultation skills. If the group were able to expand to any extent, instructional division plans might involve a subdivision into specialized subsections. One would manage elements relating to development, maintenance, and improvement of the language system itself. Another subsection would have to do with training people to make use of that language and helping instructors program curriculum elements in it, plus documentation of such efforts. Perhaps a third subgroup would act as liaison with users, sending information on local and remote operations to a mailing list of people interested in what we are up to. Another subgroup might handle the development of conversions from curriculum materials written in the other author-languages in other places. I will mention this point again a little later.

DEVELOPING INSTRUCTIONAL MATERIALS

At this time, let me make a few remarks about the instructional group and how its system tries to meet some of the needs of students and teachers. This will not be the first point in these meetings where the notion and importance of corrective feedback in the development of interactive instructional materials will be expressed. Corrective feedback can be a powerful mechanism in the control of any dynamic process and is especially valuable in the development of new procedures which can not be completely predicted in advance of their operation. I think that a good deal of what we do in using the computer for instruction falls in that category.

In developing a programmed instruction sequence between man and machine, we must be particularly cautious when settling on a method which seems to work well in one instance. For these conversational operations, a change in context or setting seems to have a powerful effect on the interaction, sometimes with quite disruptive results. This concern can be addressed, I think, by arranging that such systems of man-machine communication and interaction have a mechanism by which the user can record comments about its handling of his responses or remarks on its occasional malfunction. In other words, I think it is important that there be a gripe mechanism for the user of the system, whether student or researcher. Comments should be put to use as rapidly as possible, with a subsequent improvement in succeeding interactions. The system itself ought to make such revisions as easy as possible.

A developer of such systems should leave the curriculum content in the hands of professionals in the specific subject-matter area. But he should be in a position to provide such people with methods by which they can receive corrective feedback information from students and easily review such feedback, taking corrective action.

It is possible and usual for human instructors to make use of centrally produced, standard textbooks and other curriculum aids. It is also possible for them to use textbooks—standard, nationally-distributed aids to the instructional area—and interpret such materials to fit a local context, assisting the student in understanding them.

It seems to me that it is exceedingly difficult, maybe even impossible, for computer programs—at least in their present stage of development—to accomplish this same kind of task. We should, therefore, not expect to produce centralized, standard curriculum materials for computer presentation except in very basic areas of routine drill. I think that we can try to produce examples and points of departure for a local instructor by providing these centrally produced materials, but the instructor should be in a good position to test them and modify them easily to meet the needs of the local context, customs and language usage.

There is an interesting version of this problem which occurs in arranging for a computer program to recognize and understand the language produced by a student or other user in a conversational situation. Let us assume that the author of such a program does have versatile mechanisms at hand with which to describe language elements. Even so, he cannot predict the entire range of possible responses to a question which does not severely limit the format of the reply. If the situation is such that the author can expect feedback from test subjects who face his program, then it is sufficient for him to write only an initial skeleton which he will expect to fail on first attempts. Information from users will allow him to quickly add other elements of recognition, which will rapidly improve the program.

The rate of such improvement is clearly a diminishing kind of operation. There is a very rapid improvement in this respect in the first trials, as one gets the first feedback from early subjects. After that, however, it becomes less and less a part of the problem. One can always come across a new type of respondent, perhaps a poet who uses some language which the previous people had not thought about using, but this will become a very rare occurrence.

One can imagine improving this process in a way which might make program development much less painful from the author's standpoint. Future versions of an author-language might have provisions for an active monitor or prompter terminal, where an author/instructor would sit and converse with a student who sits at a separate terminal. It is conceivable that a program could be written not only to record appropriate portions of this interaction but also to abstract, from the spontaneous responses of the author, elements necessary for the construction of automatic reply. This is probably a very big order, but a little easier for me to imagine than a completely automatic lesson-generator program. Here we are talking about a pattern recognizer of sufficient capability to abstract elements from humanly generated material. I think that this is, at least, something worth thinking about and working on.

On successive runs with new students, the program would first attempt to recognize a student's reply by virtue of previously recorded elements. In the event of failure, it would indicate at the monitor terminal that the author should insert a new human response. When this kind of thing occurred, the author would immediately come on the line with a response that he would generate. An interactive process of this sort might result in the building of a functioning program which would progressively handle more and more responses. Before long, the author could step aside, I would hope.

If a program were to be transplanted and used in a context where the language characteristics of students were different from those in its original location, a similar process would have to be undertaken in order to bring the program into line with the new setting. For example, it is clear that the language background of students in central-city schools is likely to be quite different from that found in suburban districts. A computer program which recognizes the language in one setting will quite likely fail in another. The required process of translation for such a program may result in new knowledge about language habits in the two environments. So there is a possiblity of some useful fallout from this kind of interchange and rearrangement of material.

Let us think for a moment about the requirements for language-system handling of conversational interaction. I have already suggested that a language for writing conversational interaction, built to recognize appropriate elements of naturally occurring language, should have both a high level of readability and an editing method which makes it as easy as possible for a person who has curriculum concerns at the local level to make changes to meet those needs. That person should have a means to record comments about language operation and make use of those comments to change and improve the program.

It would be especially valuable for such a system to have a subset of mechanisms for simple operation and easy entry to its use. With such mechanisms, a local teacher or curriculum coordinator could make use of the language with little effort. We expect that the system should itself instruct new users in the basic aspects and initial operations that would be necessary. The system should be capable of handling and storing text in a very flexible fashion and at the same time should make use of rapid recognition methods in tracking the meaning of the subjects' responses.

Basic recognition methods should be sufficiently rapid so that the pace of conversational interaction is not badly distorted. While it should be possible to designate a specific sequence of programmed responses to subjects, there also exists a need for random choice mechanisms so that an author can call on a varied output. Future systems should probably have the development of adaptive mechanisms to improve their responses as a result of increased experience with many subjects.

There are already a variety of what might be called CAI author-languages. While we feel there are many advantages to the approach we have taken with PILOT, we recognize that we have spent a lot of time in working on this system. In the meantime, there has been a considerable amount of effort expended elsewhere in the development of interesting and useful curriculum materials in other languages. So we are interested in translation from one language of this type to another. This does not seem to be an insurmountable problem.

I believe that there are many potential advantages to sharing between centers. First of all, one can conceive of transplanting the whole system from one place to another, that is, what usually amounts to new implementation of the language on a new machine. This can be a difficult process, depending to some large degree on how the language system is built. In our case we have tried to make PILOT relatively readable by writing the system itself in a high-level language, and we have had some success in implementation on other machines. The most notable success is a translation to the SDS 940 time-sharing system. In this instance, it was a manual translation, but the process went amazingly rapidly, in comparison with other projects of similar type, probably because of the fact that the original system was written in a high-level language.

I have already mentioned that the sharing of curriculum elements is likely to require translation from one author-language to another. I believe that experimentation in this area is quite valuable because of the great advances that could accrue from the transplant of curriculum materials from one professional school to another. A particular advantage in such sharing is the gathering of evaluative data on such programs. Larry Stolurow was discussing with me ways to improve the evaluation process—to reduce those extensive delays which occur when materials are evaluated at only one school. After the first group or class of students tries a program there may be a lapse of as much as a year before another appropriate class becomes available for further evaluation. It would be extremely valuable, I think, to try those same programs in a number of settings and improve things much more rapidly.

There is also the possiblity of joint and reciprocal development of curricula, i.e., people at separate centers might combine their efforts in the development of the curriculum itself. It would be an interesting experiment to bring together specialists in adjacent areas or in the same area, with different points of view and varying abilities to collaborate, as the joint authors of a textbook might. In this instance I can imagine them interacting with the same system, perhaps even calling in to the same machine from different centers and reporting the development of materials and their trials of them.

EDUCATIONAL NETWORKS

Let me turn from this to what I want to say briefly about networks. I conceive of educational networks as being a continuum of possibilities, if the definition is kept rather loose. The full-scale network might be considered the direct interconnection of machines at different campuses where actual sharing of computer load could take place. If one place became overloaded, data would be shipped to a remote point for processing. There are efforts underway along this line, primarily those supported by the Department of Defense and its collection of time-sharing operations at various high-powered centers around the country.

A second level might be the reciprocal remote usage of time-sharing computers by using an appropriate terminal to call in from the remote points. This is a network only by virtue of the fact that the telephone company is a network. By making use of that existing network, it is certainly conceivable that educational institutions could do more and more of this kind of network activity. Someone who wanted to try a system that existed uniquely at our center could arrange to call in from an appropriate terminal anywhere, try the system out, and decide whether they want to try to transplant it or not. We might find that there is a program that we would like a specialist in one curriculum-area of our professional school to experience. The program exists at the Harvard Medical Center, let us say. We would arrange for our specialist to try it out remotely and would simply pay the long distance charges, obviously a much lesser expense than sending him to Harvard or making a full-scale attempt to transplant the system. That kind of network arrangement may prove to be especially useful.

A third level is the sharing and translating of programs mailed from one place to another. I think, in that sense, we are simply considering the mail system as the network mechanism. There are attempts underway to develop a kind of clearinghouse of information about available programs which would make this kind of interaction more useful and generally available. An enterprise called EDUCOM, which has members from many universities in the country, has throughout its existence been interested in networks at all the levels I have just described. This group was the primary author of a book describing full-scale networks of the first type. They have made proposals for the development of networks of the second type and they are currently trying to implement a network of the third type by acting as a clearinghouse of programs between university centers.

EVALUATION CRITERIA

Now let me turn back to the instructional area and make a few remarks about problems in evaluation and development of criteria for programs of this kind. Anyone who sets out to improve instructional methods soon realizes that objectives and criteria for successful instruction are seldom expressed in terms that are specific enough to be at all useful for measurement and evaluation of instructional methods and processes. When the whole system is an experimental one, such as the various means by which the computer is involved in learning and instruction, a specific listing of objectives and criteria of performance becomes especially valuable. This kind of information can be fed back to a program author, who may be in a position to compare more than one method of presentation of the curriculum materials. If the criteria are sufficiently objective and measurable, then statistical techniques such as discriminant function analysis or factor analysis might be used to discover which items of input are especially relevant to the outcome. All of these things require a good criterion.

I suppose it is a platitude to say that these objectives should be stated in terms of the observable behavior expected of a student at the time that he completes the sequence. I think that when this notion is not considered, we have many elements in professional education which go badly awry.

Students are often asked, for example, to give a list of the signs and symptoms associated with a disease. At certain points in the curriculum, students get much less practice in attempting to solve a diagnostic problem on the basis of presented symtoms, which is the reverse kind of information. I think that in this particular area interactive instruction can indeed allow a student to practice behavior which is closer to his eventual goal.

EXPLORATORY USES OF CONVERSATIONAL INTERACTION

I am now going to present some exploratory examples of the variety of CAI conversational interactions relevant to professional education. We have had a special interest in allowing and handling unconstrained responses and this has of course led us into considerable exploration of the problems of language-handling involved in this mode of operation. There is a whole continuum of possiblities, ranging from the extreme, constrained format of presenting a statement or a question and asking for a yes-or-no response, through the possibility of multiple-choice responses, fill-in responses, and completion responses, to the seemingly free-form response which, however, has subtle constraints that are very hard to pin down.

But we have tried to be as free as possible in our developments. When our language pattern-recognition methods and our processing methods failed us, and we did not recognize what the person was talking about in his response to the program, our usual recourse was to fall back on a greater restraint, with a more solid boundary on the context. The extreme case of this is, "Would you answer yes or no to the following: . . ." I think you will find cases of this sort in the examples to be shown.

In trying to develop this kind of language-handling capability, one of our early attempts, for test purposes, was to use the kind of verbal questions used in the individual administration of an intelligence test.

Example 1 shows the kind of simple-minded early approach which let us play with the variety of responses that a person might give to this kind of question. We encouraged the people responding to these questions to make every attempt to beat the system, so that we had lots of people trying to play pranks and give partial responses or to give responses that would have to be considered correct but had not been anticipated.

EXAMPLE 1

```
     WHAT STATE ARE WE IN?

. I think we are in California

     RIGHT, AND ON THE FIRST TRY.

     WHO WAS THE FIRST PRESIDENT OF THE UNITED STATES?

. George

     YOU MUST KNOW MORE THAN JUST THE FIRST NAME . . .
     WHAT IS HIS LAST?

. Washington

     NOW YOU'VE GOT IT.

     HOW MANY PINTS MAKE A QUART?
```

```
. two

    THAT'S THE WAY!

    WHAT IS THE CAPITAL OF ITALY?

. Is it the vatican?

    NO, IT'S NOT THE VATICAN, CHOOSE ONE OF THESE . . .

    MADRID   ALGIERS   VIENNA   LISBON   ROME   ATHENS

. Athens

    YOU SHOULD LOOK THAT ONE UP.
```

Notice that the remarks printed entirely in capitals and indented are those printed by the computer. In this system, the typing ball returns to the left of the page and prints a period, which indicates to the user that he is free to make a response.

A similarity question, such as that in Example 2, is one which can have a fairly free response and therefore has to have a fairly complicated background of possiblities, both at a concrete and at a more abstract level, to make appropriate remarks about the response.

EXAMPLE 2

```
    THIS NEXT SECTION HAS QUESTIONS ON THE SIMILARITY
    OF THINGS.

    HOW IS AN APPLE LIKE AN ORANGE?

. They are both round.

    THAT IS ACCEPTABLE, BUT TRY TO GIVE A MORE BASIC
    SIMILARITY.

. Both of them grow on trees.

    TRY ONCE MORE TO THINK OF SOMETHING MORE BASIC
    OR GENERAL.

. I don't know any more.
```

YOU COULD SAY THAT THEY ARE BOTH FRUIT.

A proverb (Example 3) is an even worse case, in which the response can be very abstract and still carry some of the meaning appropriate to an interpretation of the proverb. In this example, the response, "They might break the glass," would be considered a very concrete, non-explanatory kind of response to the question.

EXAMPLE 3

NOW I WOULD LIKE TO ASK YOU ABOUT SOME PROVERBS . . .

SEE IF YOU CAN TELL ME THE GENERAL MEANING OF THESE PROVERBS, OR WHAT A PERSON WOULD MEAN IF HE SAID THEM TO YOU . . .

FIRST TRY THIS ONE . . .

A BIRD IN THE HAND IS WORTH TWO IN THE BUSH.

. Well, you can be sure of having the one in your hand for dinner.

YOU HAVE THAT MEANING IN HAND. HERE IS ANOTHER . . .

PEOPLE WHO LIVE IN GLASS HOUSES SHOULD NEVER THROW STONES . . .

. They might break the glass.

I GUESS YOU COULD INTERPRET IT THAT WAY, BUT TRY TO BE MORE GENERAL IN YOUR ANSWERS.

Example 4 shows a fill-in technique, which makes things a little easier. The previous example was of the more difficult type.

EXAMPLE 4

NOW I WILL ASK YOU TO FILL IN SOME BLANKS ABOUT PROVERBS . . .

THIS PROVERB SAYS IT IS NO USE TO CRY OVER SPILT MILK. HERE, "SPILT MILK" COULD REFER TO ANY ____________ .

(TYPE ONE WORD, PRESS RETURN)

```
. drink

    NOT WHAT I HAD IN MIND — TRY IT THIS WAY . . .
    THIS PROVERB TELLS YOU NOT TO ____________ ABOUT
    SOMETHING THAT IS ____________ .

    (TYPE TWO WORDS, THEN PRESS RETURN)

. worry     spilled

    YOU HAD ONE OF THEM RIGHT — LET'S GO ON.
```

Example 5 shows another situation in which you can imitate a picture arrangement sequence or something of this sort. This kind of thing is often done with a sequence of cartoon frames, putting them in an appropriate order to tell a logical story.

EXAMPLE 5

```
    I WILL SHOW YOU SOME SETS OF STATEMENTS. ARRANGE
    THEM SO THEY TELL A LOGICAL STORY, THEN SHOW ME
    YOUR ARRANGEMENT BY TYPING THE CORRESPONDING
    LETTERS.

    A. BATTER HITS BALL.
    B. BATTER SCORES HOME RUN.
    C. PITCHER THROWS TO BATTER.

    (TYPE THREE LETTERS, THEN PRESS RETURN KEY)

. C A B

    FINE, HERE IS ANOTHER . . .

    A. GANGSTER KILLS MAN.
    B. MAN IS FOLLOWED BY GANGSTER.
    C. MAN WALKS DOWN STREET.

    NOW TYPE THE SEQUENCE OF LETTERS, PRESS RETURN.

. A B C

    NO, DEAD MAN CAN'T WALK.
```

While not a difficult method, from the computer-processing point of view, Example 6 demonstrates a reasonably difficult problem—and is one which is a good deal more difficult if your information is limited to just the listing of items A through G. It takes a bit of thought to put those elements together. This illustrates the possibility of a prompt and a re-try with some additional information added.

EXAMPLE 6

```
    HERE IS ONE A LITTLE MORE COMPLICATED . . .

    A. THE HORSE WAS STAGGERING UNDER HIS LOAD.
    B. HIS DONKEY WAS LOADED WITH SACKS OF SALT WHILE
       HIS HORSE WAS LOADED WITH SACKS OF SPONGES.
    C. HIS HORSE TROTTED ALONG EASILY.
    D. A MAN WAS TRAVELLING WITH A DONKEY AND A HORSE.
    E. THE DONKEY TROTTED ALONG EASILY.
    F. HIS DONKEY WAS STAGGERING ALONG UNDER THE LOAD.
    G. THEN THEY HAD TO CROSS A STREAM, AND SWAM THRU
       DEEP WATER.

. E A D B G F C

    I DON'T THINK YOU HAVE THE IDEA.
    TYPE YES IF YOU WOULD LIKE TO HAVE A HINT AND TRY
    IT AGAIN.

. yes

    ***THINK OF WHAT HAPPENS TO THE SALT AND***
    * TO THE SPONGES WHEN THEY GET IN THE WATER*

. D B C F G A E

    FINE, THAT WAS ONE OF THE ARRANGEMENTS I HAD
    IN MIND.
```

There have been many approaches to the use of the computer for content analysis of language material.* I would like to

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*Starkweather, J.A., Overview: Computer-aided approaches to content recognition. In G. Gerbner *et al.* (eds.) *The Analysis of Communication Content*, New York: John Wiley & Sons, 1969, 339-342.

make just a few remarks about that area of research. It is possible to arrange computer approaches to content analysis on the dimension of the importance of having an immediate response. At the extreme of leisurely response we might find research which is involved with the analysis of many different individuals whether they be speakers or writers, in different situations. Included here are attempts to analyze written content in order to decide whether Jefferson or Madison wrote a specific paper or whether Shakespeare or Bacon wrote a particular play. The idea is to try to develop measures of the formal characteristics of language usage which would indicate things of this sort.

At the extreme of immediate response we have something like what we are dealing with here: a need to cope with a particular point in an immediate conversation with a specific person. In the first area, content analysis of documents and similar investigations of this type, the investigator usually deals with standard units of writing or speech, i.e., words or phrases which might suggest anxiety, words that suggest anger and so on. We could classify collections of terms depending upon the interest of the investigator. We assume that by studying the relative frequency with which such units occur, we can produce a new and useful description of a document or a transcript of a speech. One such program is called the General Inquirer. Phillip Stone from Harvard is the author. This program expects incoming textual data to be arranged as sentences and it examines the text by making references to a dictionary of word stems—a huge dictionary—in order to handle virtually all terms that might be included. The approach, then, involves an effort to produce a dictionary which, while specialized in coverage, nevertheless attempts to handle the vocabulary usage of different speakers. Therefore, it needs to become quite large, containing many thousands of words for use on text to be analyzed.

There is another approach which has been used with verbatim transcripts of spoken material and has tended to focus on word usage. The computer has been used as a clerical assistant to develop a form of specialized dictionary from the material itself, rather than from a general-purpose dictionary, many words of which will not exist in these documents. This kind of approach results in a statistical definition of word groups which are associated with each other in an individual speaker's usage. There are studies which have applied this to psychiatric word-usage. I mention these approaches to content analysis for the following reason. If one gets into the area of developing simulated patients or case examples which are conversational in nature, one may wish to have tools at hand with which to analyze the existing characteristics of language usage for those purposes. Some of these more formal methods of content analysis may turn out to be necessary in developing the limited dictionary that you may need to use in the development of curriculum materials.

When we have become involved in the use of computers for interaction between man and machine, it becomes necessary to find methods for immediate content analysis which can be specified and programmed as an entirely automatic process. The machine has to have a means of recognizing language responses by a subject and of rapidly developing appropriate replies in return. We can look upon such activities as attempts to simulate human information processes. We can build machine methods to imitate human activity in as many respects as possible. Nevertheless, we use whatever machine methods seem practical at the moment, in view of current machine capability and present state of knowledge about language. These methods may not look much like human information processes.

There are a number of approaches to this kind of study of conversational interaction. I might remind you of Kenneth Colby's work; of several other men, Bellman, Friend and Kurland, who did some work of this type; and finally of the work at MIT of Joseph Weizenbaum, who has been particularly interested in the credibility of a machine response to a subject who is interacting in a conversational fashion. In his work we see a reliance on immediate context in the development of rules of language processing which may apply only to a specific combination of attributes—not only of the individual subject being being studied but also of the particular point in the conversation.

My concerns have been similar to his. Conversational ability becomes possible if we are able to develop a form of content analysis that can deal with language fragments which are often incomplete or incorrect from a grammatical standpoint. The kind of language processing engaged in by the linguist does not help a great deal. Recognition of the meaning of such fragments can lead to conversational responses which indicate what we may call "understanding" by the computer program. It will be able to make responses that indicate appropriate or reasonable tracking. Responses have to be considered as specific to the context surrounding a particular point in the conversation and they require what amount to miniature dictionaries to operate within such specific contexts.

Let me present some further examples.

Example 7 shows interaction with a simulated dental patient that some of the people at the U.C. Medical Center have been developing. The format is the same as before, with the periods at the left indicating a response by the subject. This program acts as though it represents a specific patient coming to a dentist and is capable of answering questions corresponding to history-taking procedure.

EXAMPLE 7

```
    I COMPLAINED TO MY PHYSICIAN ABOUT THIS SORE IN MY
    MOUTH, AND HE REFERRED ME TO YOU. HE WOULD LIKE
    YOUR OPINION.

. Where is the sore located?

    THE SORE IS ON THE INSIDE OF MY RIGHT CHEEK AND ON
    THE RIGHT SIDE OF MY TONGUE.

. Have you ever had one like it before?

    NO.

. How long have you had this one?

    I FIRST NOTICED IT ABOUT 2 MONTHS AGO, AFTER I HAD
    BEEN EATING SOME TACOS.

. Have you tried any kind of treatment or mouthwash?

    NO, I WAS HOPING IT WOULD GO AWAY.

. Has it been getting any better?

    IT'S BEEN ABOUT THE SAME EVER SINCE I FIRST NOTICED IT.

. Does it cause you any trouble eating?

    I CAN'T EAT SPICY FOODS, BUT EVERYTHING ELSE IS OK.
```

. Does anything else make it hurt?

IT SEEMS WORSE WHEN I EAT SPICY FOODS, AND
SOMETIMES WHEN I'M NERVOUS.

. Anything else make it worse?

I THINK IT'S WORSE WHEN I'M HAVING MY PERIOD.

. Does smoking bother it?

I'VE CUT DOWN MY SMOKING BECAUSE THAT SEEMED TO
IRRITATE MY SORE.

Example 8 shows the same patient being asked different questions. Some of the same information appears. It is clear that the student can obtain more information under one strategy than another, and therefore can be directed and rewarded, if the clinical instructor really knows what he wishes to have happen in that regard.

EXAMPLE 8

I COMPLAINED TO MY PHYSICIAN ABOUT THIS SORE IN MY
MOUTH, AND HE REFERRED ME TO YOU. HE WOULD LIKE
YOUR OPINION.

. Is it a painful sore?

YES.

. What kind of pain is it?

IT'S A BURNING PAIN.

. Is there anything special that makes it hurt?

IT SEEMS WORSE WHEN I EAT SPICY FOODS, AND
SOMETIMES WHEN I'M NERVOUS.

. Anything else?

I'M NOT SURE WHAT YOU MEAN, DOCTOR.

. Does anything else make it hurt?

I THINK IT'S WORSE WHEN I'M HAVING MY PERIOD.

Example 9 provides a third example, in which there seems to be a little repetition on the part of the interviewer which develops a slight resentment in the patient.

EXAMPLE 9

I COMPLAINED TO MY PHYSICIAN ABOUT THIS SORE IN MY MOUTH, AND HE REFERRED ME TO YOU. HE WOULD LIKE YOUR OPINION.

. How long have you had the sore?

I FIRST NOTICED IT ABOUT 2 MONTHS AGO, AFTER I HAD BEEN EATING SOME TACOS.

. Is it painful?

YES.

. What kind of pain is it?

IT'S A BURNING PAIN.

. What kind of a pain?

IT FEELS LIKE IT IS ON FIRE.

. Please describe the pain.

I TOLD YOU, DOCTOR, IT BURNS!

Now I am going to show you some brief examples of a psychiatric patient and, I might say, a somewhat more fully developed patient in the sense of having lived longer and interacted with more interviewers.*

You will notice that in the case shown in Example 10 there

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*Starkweather, J.A., Kamp, M., and Monto, A., Psychiatric interview simulation by computer. *Methods of Information in Medicine.* 1967, 6, 15-23. *Also in Proc. 7th IBM Med. Symposium,* 1965, 291-308.

is a little bit of introductory information which lets the interviewer know what is expected of him. Once again, our major purpose in working with the psychiatric patient in simulating this particular kind of case was not only to make an interesting demonstration but also to take an area of minimal constraints which would push us pretty far in handling a variety of free-form responses. Showing just one series of this, of course, does not give you a good indication of the variations that can occur under the different interviewing strategies. I will just assure you, though, that there are a variety of things that can appear from this patient.

EXAMPLE 10

```
THE PATIENT ENTERS YOUR OFFICE. HE IS A SLENDER,
CONVENTIONALLY DRESSED MAN APPEARING ABOUT THIRTY
YEARS OLD. HIS NAME IS JOHN SANDERS. YOU SEAT
YOURSELF AND ASK HIM TO BE SEATED. HE SITS DOWN
AND SAYS . . .

THANK YOU.

. How old are you, Mr. Sanders?

I'M 33.

. Have you been to a psychiatrist before?

NO.

. Why are you here today?

WELL, MY WIFE WANTED ME TO COME.

. Your wife?

IT'S NOT MY IDEA, THAT'S FOR SURE.
MY WIFE JUST TOLD ME I OUGHT TO SEE A PSYCHIATRIST.
SHE SAID SHE WAS GOING TO LEAVE IF I DIDN'T GO.

. Why did she say that?

I DON'T WANT TO TALK ABOUT MY WIFE.
```

. Why not?

I JUST DON'T WANT TO TALK ABOUT IT.

. Well, then tell me about yourself.

TELL YOU ALL ABOUT MYSELF, HUH?

. Yes.

WELL, I'M A PAINTER . . . NOT ONE OF THEM ARTISTS, YOU KNOW . . . A HOUSEPAINTER. MAKE PRETTY GOOD MONEY AT IT . . . FOUR SEVENTY-FIVE AN HOUR, AND BEEN WORKING PRETTY STEADY, TOO.

. I see.

LATELY I'VE BEEN WORKING MOSTLY FOR THIS CONTRACTOR, GIANTELLI. WE'RE ON AN APARTMENT JOB NOW. TWENTY-TWO UNITS OVER NEAR THE PARK.

. Please go on.

SAY, HOW COME YOU WANT TO KNOW SO MUCH ABOUT MY JOB FOR?

. Well, I thought you wanted to tell me about it.

YOU DON'T THINK THEY'LL FIND OUT AT WORK ABOUT ME COMING HERE, DO YOU?

. Why do you ask?

IF THEY KNEW I WENT TO SEE A PSYCHIATRIST, THEY'RE LIABLE TO THINK THERE'S SOMETHING THE MATTER WITH ME.

. What would they think?

I DON'T WANT TO GO INTO THAT.

. All right.

GEE, DOC, I DON'T KNOW WHAT TO TELL YOU. ASK ME

SOME QUESTIONS, THAT WAY YOU CAN FIND OUT WHAT
YOU WANT TO KNOW.

. I need to know more about the reason you are coming to see a psychiatrist.

WELL, I DON'T KNOW . . . ANYWAY, WHAT I CAME ABOUT IS,
MY WIFE SAYS SHE CAN'T STAND THE WAY I ACT ANYMORE.

. How do you act?

WELL, YOU KNOW WOMEN . . . THERE'S ALWAYS SOMETHING
BUGGING THEM, BUT IT'S PRETTY HARD TO FIGURE OUT
WHAT IT IS.

As you can see there is a good deal more. The patient may become silent, or difficult in one way or another, and in this particular case, he finally walked out.

In a related way, we have the experience of a medical student who worked this last summer with Dr. Martin Kamp of our staff, and developed a simulation of a medical patient who complained of shortness of breath. That is, that would be her complaint if she were appropriately questioned. I would like to quote just a part of the work of this medical student because I think you will get some sense of the student's viewpoint after his having had the experience of working on this kind of material.

It was decided that to have just an interaction between student and patient would not be using the full potential of the system. Rather, some means of evaluating and commenting on the student's performance should be incorporated into the program. If the student asks an inappropriate question, he receives a message from the professor. The professor's comments are distinguished from those of the patient by being enclosed in asterisks. The program begins as shown in Example 11.

EXAMPLE 11

MRS. ERIC KRANKHEIT IS A 34-YEAR-OLD, WHITE,
MARRIED HOUSEWIFE. YOU ARE THE ATTENDING PHYSICIAN
AND MUST TAKE THE HISTORY. YOU ARE FORTUNATE FOR
DR. WATCHIT IS HERE TO MAKE SURE YOU TAKE A GOOD

```
     HISTORY. YOU CAN TELL WHEN HE IS SPEAKING FOR HIS
     COMMENTS WILL BE ENCLOSED IN ASTERISKS.

     *HELLO DOCTOR. I'M DR. WATCHIT. GOOD LUCK.*

     YOU MAY BEGIN THE INTERVIEW.

. What kind of trouble have you been having?

     I'VE BEEN SHORT OF BREATH.

. When did it start?

     IT STARTED ABOUT FIVE YEARS AGO.

. What is it like?

     NOW OR WHEN IT FIRST STARTED?

. When it first started.

     WHEN IT FIRST STARTED IT WASN'T TOO BAD. MY HUSBAND
     AND I LIKE TO HIKE A LOT, AND BEFORE I NEVER HAD ANY
     TROUBLE KEEPING UP WITH HIM. BUT THEN I STARTED
     GETTING SHORT OF BREATH IF WE HAD TO WALK UPHILL A
     LONG DISTANCE, AND I'D HAVE TO STOP AND REST A FEW
     MINUTES. IT KEPT GETTING WORSE AND ABOUT THREE
     YEARS AGO I BEGAN TO HAVE TROUBLE CLIMBING
     STAIRS. I'D WALK UP A FLIGHT OR TWO AND BE SO SHORT
     OF BREATH I'D HAVE TO STOP AND REST AWHILE.
```

The student who wrote this program said that he recognized that each physician or medical student has his own individual method of history-taking and that although these methods differ in sequence and wording, they all might get the same amount of information. He wanted to limit the complexity of the program—and get through with his work during the summer—so he decided to put certain restrictions on the sequence of questions that could be asked.

He permitted the interviewer to ask about various symptoms, but also required that a number of basic questions be asked about one symptom before asking about another symptom. That is, he restricted the system by requiring that one area had to be explored before going on to another. The number of basic questions varied from four to eight depending upon the symptom.

On the other hand, there were some symptoms which he felt were so closely allied that he allowed them to interrelate. Here the interviewer could, in fact, jump around in an area of two or three related symptoms, such as cough, sputum, and blood.

Example 12 gives an idea of how Dr. Watchit came into the picture now and then.

EXAMPLE 12

. Do you have a heart murmur?

WHAT?

. Have you ever been told that you have a heart murmur?

THERE ARE STILL SOME QUESTIONS YOU SHOULD ASK ABOUT HER HEMOPTYSIS

. What are they, Dr. Watchit?

WHY DON'T YOU ASK IF SHE NOTICED ANYTHING THAT WOULD PRECIPITATE OR BRING ON THE ATTACKS?

. Did you notice anything that would precipitate the attacks?

I DON'T UNDERSTAND.

. Did you notice anything that would bring on the attacks?

NOTHING. THEY'D JUST START AND STOP BY THEMSELVES.

Once again we have some kind of mechanism for the handling of unrecognized questions and it seems to work in this instance.

The consultant (Dr. Watchit) later on advises on other possibilities as well, as when the interviewer asks, "Do you have any trouble with your vision?"

Answer: "What?"

Question: "Do your eyes bother you?"

Here Dr. Watchit says, "Doctor, are you considering the possibility that the patient may have some kind of heart trouble such as failure, valvular disease, or maybe even ischemic heart disease?"

The student answers, "Should I be?"

"Would you please answer my question with either yes or no."

Answer: "No."

"I think you should entertain the possibility. It would be helpful to question the patient further and explore this possibility."

We have already seen an example in the dental patient of what may happen as a result of repetitive kinds of questioning. Here is an example, where the student asks, "Do you ever cough up any blood?"

Answer: "Yes."

Question: "Is it bright red or sort of brownish?"

Answer: "I don't remember too well but I think it was bright red."

Question: "What color was it?"

Answer: "Like I said, it was bright red—I think."

Question: "Was it bright red?"

Answer: "How many times are you going to ask me that?"

Question: "What color did you say it was?"

Dr. Watchit then comments, "You had best go on to something else."

You can see that the student-author had fun and learned a good deal from this situation. Now let me give you a brief example of how some of this is done.

EXAMPLE 13

PILOT CODING

```
     T: PLEASE TYPE YOUR FIRST NAME.;

LABEL: A:    ;

     T: GLAD TO MEET YOU, "LABEL".;
```

PILOT CONVERSATION

```
     PLEASE TYPE YOUR FIRST NAME.
```

```
. Fred

        GLAD TO MEET YOU, FRED.
```

At the top of Example 13, there is some coding in PILOT which indicates, "I want computer to type"—that is what the "T" means. Then the program asks, "Please type your first name" and it sets up the answer. The program is going to accept future answers and store them by name, which in this case is "Label," but could be anything. Then it proceeds to type, "Glad to meet you, 'Label.'" This means that it will retrieve whatever name was stored.

The conversation resulting from this asks the student, "Please type your first name." He types in "Fred." It then says, "Glad to meet you, Fred." This is an example of how all or a portion of a person's response can be stored away under a name and brought back at a later point in the program. The program can get very friendly by this means.

Example 14 shows three different interactions with a portion of a question-type program. You can see this material handled in three different ways. The first case is a correct answer; the second case is a recognizable but not completely correct response, which gets some help; and the third case is an unrecognized answer.

EXAMPLE 14

CONVERSATION WITH A PILOT PROGRAM

```
    (1)  A FEMUR IS A ----- .
            (TYPE A WORD)

. bone

           THAT IS CORRECT.

    (2)  A FEMUR IS A ----- .
            (TYPE A WORD)

. part of the thigh

           YOU ARE CLOSE, TRY AGAIN.

. one of the leg bones
```

```
        THAT IS CORRECT.

   (3)  A FEMUR IS A ····· .
           (TYPE A WORD)

. small furry animal

        SORRY, TRY AGAIN.

. rodent

        SORRY, TRY AGAIN.
```

Example 15 demonstrates the kind of coding that is capable of producing those three different forms of output. The computer types the first two lines, and then accepts an answer. In this instance, the recognition item is "bone" and if "bone" appears there is a positive response, i.e., recognition, which says, "That is correct." Having gotten to that point, there is a control item which says, "GJUMP TO END." This means that if there is recognition, that is if the good response appears, it is going to jump to "End" for control of the program.

EXAMPLE 15

AN EXAMPLE OF PILOT CODING

```
    T: A FEMUR IS A ····· . ;

    T:    (TYPE A WORD) ;

GO: A:   ;

    R: BONE;

    G: THAT IS CORRECT.;

    C: GJUMP TO END;

    R: LEG, THIGH, HIP;

    G: YOU ARE CLOSE, TRY AGAIN.;

    B: SORRY, TRY AGAIN.;
```

```
     C: JUMP TO GO;

 END: E:  ;
```

In the program shown in Example 16, items are recognized for the first and second responses; but for the third response, the word "uncommon" is given as the answer. It is not recognized and the computer types, "Try it again. What kind of characteristics differentiate people from one another?"

EXAMPLE 16

```
    THE REASON WE ARE ABLE TO FORMULATE SOME GENERAL
    PRINCIPLES ABOUT HUMAN NATURE IS THAT THE BASIC
    HUMAN MOTIVATIONS ARE ____________ BY ALL
    PERSONS.

. known

    THAT SOUNDS LIKE YOU MAY HAVE THE RIGHT IDEA, BUT
    I CAN'T BE SURE. PLEASE TRY AGAIN FOR A MORE
    SPECIFIC WORD.

. shared

    RIGHT, AND AN EXAMPLE OF THESE "SHARED"
    MOTIVATIONS IS THE UNIVERSAL DESIRE FOR SATISFYING
    INVOLVEMENT WITH OTHER HUMAN BEINGS.

    IN ADDITION TO THE COMMON FEATURES, EACH PERSON
    ALSO HAS HIS ____________ CHARACTERISTICS WHICH
    DIFFERENTIATE HIM FROM EVERY OTHER PERSON.

. uncommon

    TRY IT AGAIN. WHAT KIND OF CHARACTERISTICS
    DIFFERENTIATE PEOPLE FROM ONE ANOTHER?

. personal

    YES, THESE ARE PART OF THE PERSONALITY, BUT THE IDEA
    IS THAT EACH PERSON HAS "UNIQUE"
    CHARACTERISTICS.
```

The author does something like the following in reviewing this operation. (See Example 17.) He enters an edit mode and the computer indicates that it is in an edit mode. The author then asks for a display of the non-matching items, where it says, "display nomatch." It displays question two and the answer, "uncommon." Moving on, he types, "Display the 'R' items for number two," and it displays a series of different word groups labeled R2A, B, C, D, and E. These different groups would, in the program itself, undoubtedly produce different kinds of output depending upon which group contained the word that was recognized in the response. The author here wants to add the word "uncommon" to one of these lists. He says, in this edit mode, "I want to add to 'R' item 2A, the word 'uncommon.' " He also adds it to 'R' item 2E.

He then asks, "Display once again the 'R' items for question 2," and here you see that "uncommon" has been added at level A and level E. The author goes back and runs the program again, entering it at question 2. The computer resumes execution of the program and puts out the lead-in for that question. The response "uncommon" is given and this time it recognizes it and says, "Yes, people usually differ."

EXAMPLE 17

```
. aaaedit

    ***EDIT MODE***

. display nomatch

    Q2 — UNCOMMON

    ***EDIT MODE***

. display r 2

    R2A — UNIQUE, DIFFERENT, INDIVIDUAL*
    R2B — PERSONAL*
    R2C — SEPARATE
    R2D — OWN
    R2E — DIFFERENT, UNIQUE, INDIVIDUAL*
```

```
     ***EDIT MODE***

. add r 2 a

     ENTER ADDITIONAL R-ITEM(S)

. , uncommon

     ***EDIT MODE***

. add r 2 e

     ENTER ADDITIONAL R-ITEM(S)

. , uncommon

     ***EDIT MODE***

. display r 2

     R2A — UNIQUE, DIFFERENT, INDIVIDUAL*, UNCOMMON
     R2B — PERSONAL*
     R2C — SEPARATE
     R2D — OWN
     R2E — DIFFERENT, UNIQUE, INDIVIDUAL*, UNCOMMON

     ***EDIT MODE***

. endedit aaa2

     IN ADDITION TO THE COMMON FEATURES, EACH PERSON
     ALSO HAS HIS ____________ CHARACTERISTICS WHICH
     DIFFERENTIATE HIM FROM EVERY OTHER PERSON.

. uncommon

     YES, PEOPLE USUALLY DIFFER FROM EACH OTHER IN
     MANY RESPECTS.
```

This is an indication of the kind of mechanism being developed to facilitate the improvement of programs—a process that recurs again and again in the development of these instruments. Authors must have a relatively easy method for doing this.

We would like to be in a position to explore a variety of terminal devices and the possible role of PILOT as a communications link to many kinds of programs, not just as a CAI language for instruction in a direct fashion. We would like to be able to question a person who comes on a terminal and does not know how to use the machine, assess his problem and act as a consultant to help him get his work done.

There are many developments in control systems for interactive computers. Most require specialized knowledge in order to learn the codes necessary to gain entry to the systems and make good use of them. We hope to use our free response, interactive, conversational language to get around this problem. For the user, who might be a student or a member of the faculty, the computer will then be an aid to learning over which he will have a considerable amount of control.

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COMPUTERS IN DENTAL SCHOOL ADMISSIONS

Thomas J. Ginley
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In 1975, approximately 15,000 applicants will participate in the Dental Admission Testing Program and will submit at least 100,000 applications to dental schools. In 1969–70, the 11,000 candidates submitted approximately 60,000 applications to the dental schools in the United States. There is no question that, as the number of candidates continues to increase, each will find acceptance by his preferred school more and more difficult to obtain. As a direct result, the dental applicants are forced to apply to an increasing number of schools in order to ensure consideration and eventual admission to some dental education program.

From an administrative and clerical standpoint, the paperwork demanded in processing this volume of candidates exceeds the normal capabilities of admission committees. The magnitude of the problem becomes apparent when one realizes that these candidates will submit not only 100,000 aptitude test scores but in all likelihood will submit 100,000 transcripts from undergraduate colleges, 200,000 letters of recommendation, and a variety of other documents and statements pertaining to their admission qualifications.

The sheer size of these numbers will confront the admission committees of the various dental schools not only with a magnified clerical problem but, more importantly, with more difficult decisions in the selection of candidates for the dental education programs. Therefore, if the dental schools in the future are going to continue to select the most qualified candidates, a system must be developed to meet the expanding admissions problem by providing dental schools with a procedure superior to the method currently in use.

Potential solutions to the problem now exist, if one is willing to consider the alternatives available. It might be possible, for example, to establish a system similar to the National Internship Matching Program. This system allows medical school graduates and hospital administrators to match their intern preferences on a national basis. The candidates list, in the order of preference, the hospital internship appointments of their choice and the subscribing hospitals have an opportunity to also indicate the candidates of their choice. The matching procedures are accomplished through the use of computers. Although there were many initial problems related to the development of the National Internship Matching Program, it is generally agreed that, on the whole, the hospitals are pleased with the results.

It is conceivable that dental schools could cooperate in a similar venture. It would be possible, as has been suggested in numerous papers presented at annual meetings of the American Association of Dental Schools, to develop a centralized application system for dental school applicants. Such a system could be installed in a progressive manner as it earned acceptance by the dental schools. For example, the dental schools would not initially use a computer admission program to select their students. The system's first phase would be a clearinghouse whereby candidates apply once to a central system which would then process all of the records and forward duplicate copies to the institutions. In this way at least a portion of the clerical work would be diminished on the part of both the candidates and the individual dental schools. This initial system, however, would be least effective in reducing the total clerical work of the dental schools but it would reduce the workload of the undergraduate colleges and applicants in providing transcripts and letters of recommendation.

A second level of an application system could involve initial screening of candidates. In this instance, not only would the centralized applicant system clerically process the papers and reports necessary for each of the schools, but would also screen out those individuals who do not meet the established pre-admission requirements of the individual institution. For example, applicants might apply to Emory University's School of Dentistry through the application system. If Emory was then requiring three years of pre-professional education prior to considering any candidate for admission, all individuals applying to that institution with less than three years of pre-professional education would be eliminated. As another example, a state dental school might accept students only from within the state. Nonresident applicants, therefore, could be screened out automatically through the use of this computerized application system. Through the use of this second level system, dental schools would received a reduced number of applications to process and consider for admission, but final selection would be left exclusively to the individual institution.

The third level, and the least acceptable to the dental schools at the present time, would be the actual selection of candidates by the use of a computer. While there is no question that computer selection is possible, I am sure we would all agree that the final decision governing acceptance to a professional school should not be based solely on formulas included in a computer program. There is, however, an increasing awareness that something must be done in the area of admissions, and perhaps a compromise system can be developed with the cooperation of all of the dental schools.

The Association of American Medical Colleges recently introduced, on a pilot basis, a centralized application system. Several medical schools cooperate by accepting application information from a central office rather than compiling it on an individual basis. While the results of this pilot venture will undoubtedly be interesting and applicable to the dental education process, it is unacceptable in my view to try to introduce such a system by the means of pilot programs. If the dental schools are interested in developing, on a national basis, a centralized system for processing dental school applications, it is essential that all of the dental schools cooperate in the initial venture. I would suggest that in the beginning, only the first two phases of the program outlined in this paper be considered by the American Association of Dental Schools. The proposed system would not make final selection of candidates to dental school but would only screen out individuals unacceptable to each institution. Secondly, the dental schools would receive a computer print-out of all applicants. The listing would include traditional information such as undergraduate course and grade point average, (pre-professional) institutional identification, dental aptitude test scores, letters of recommendation, and other miscellaneous information viewed as essential by the dental schools.

As an initial step, however, it would be necessary for all the dental schools to accept a common application form. Also, it would be necessary that the schools not require original transcripts from the undergraduate colleges, but accept the computer print-out from the national application system. This might create certain legal and administrative difficulties in universities, but probably these problems could be solved in such a way that a national program would be acceptable to all dental schools.

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OHIO STATE REGIONAL MEDICAL PROGRAM COMPUTER-ASSISTED INSTRUCTION STUDY

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Computer-assisted instruction (CAI) at the Ohio State University is at present supported through the combined efforts of the College of Dentistry, the College of Medicine, and the Ohio State Regional Medical Program. As it originally developed on this campus, CAI was solely the undertaking of the College of Medicine. Later, the College of Dentistry and the Regional Medical Program became involved.

Early in 1965 the medical-dietetic section of the College of Medicine developed a series of computer-based exercises to assist hospital dietitians in determining nutritive values for special diet planning. Although not as instructional in nature as a didactic program developed for use via a computer system would be, these exercises generated an appreciation for and an interest in the total potential value of CAI as a viable instructional method at Ohio State in the health areas.

An outgrowth of this experience was the design and development of a CAI program of review material in gross anatomy for medical students on an independent study track within the College of Medicine. This CAI material was identified and written by medical students who had just completed the course in gross anatomy. It was well received as "tutorial self-evaluation" by the students. It answered (on an individualized basis) their need to know their progress in relation to their electing to remain in the traditional lecture/dissecting section track. This course has been rewritten recently and is now used in conjunction with the anatomy program in the University Medical School.

In 1968, the Department of Biochemistry gave released time to a faculty member to write tutorial self-evaluation CAI material for dental students in a course on physiological chemistry. Dr. Helen Wikoff completed this material during the fall quarter of 1968 for use by the entire sophomore class in the College of Dentistry. The experience was informative. The sophomore class numbers 155 students at Ohio State but only three 1050 IBM terminals were available to the students.

Scheduling for all students was nearly impossible, despite an 8:00 a.m. to 10:00 p.m., seven-days-a-week, CAI operating schedule, and was complicated by the fact that 60 medical students were also using the system and the same terminals for gross anatomy, and by the fact that the 8:00 a.m. to 5:00 p.m. use was sporadic due to other scheduled classes. Needless to say, it became chaotic at times, since both CAI courses are approximately 14 hours long.

Student response and attitudes varied. The course material was well written and slanted toward practical, clinical, dental application. However, some students felt they needed to beat the system, and did not fully realize that the material was an aid in self-evaluation of their own progress in the course. Considering that self-evaluation is a new concept to students who are used to a lock-step curriculum, especially in dentistry, the initial attitudes were not that surprising. Many students did feel it was an aid in understanding the material and an excellent review medium prior to examinations.

In August of 1968, the Ohio State Regional Medical Program was funded for a feasibility study to test the use and usefulness of CAI in meeting the continuing education information needs of health professionals in the local community. The University Hospital's IBM 360/40 disk operating system (used for the courses just described) was the basis for a network connecting four community hospitals in central Ohio by data telephone line. IBM 1050 teletypewriter terminals were placed in each hospital. This network presently includes a total of ten hospitals throughout Ohio. Course materials developed for this project in its initial year included *Care of the Patient with Coronary Heart Disease*, *Anticoagulant Medication*, *Stroke Rehabilitation*, and

Diagnosing the Red Eye. These and the Medical College programs became available for use at all terminals.

A course entitled *Oral Cancer Recognition* was planned and written by Drs. Robert Finch, C.J. Cavalaris, and Gerald Gaston from the Divisions of Oral Pathology and Oral Surgery at the Ohio State University College of Dentistry, early last spring. Since this program is directed quite aptly to a group such as is gathered here, I will expand on some of the notions on which this course was developed and then give a very brief illustration of one aspect of the total course sequence.

The course authors designed the *Oral Cancer Recognition* course to reflect, as nearly as possible, the clinical practice of dentistry and medicine involved in diagnosis making. A simulation sequence was established for six clinical cases to permit the learner to interact, as in a clinico-pathologic conference, with the computer program to develop a freely structured history, physical examination, and laboratory data. When sufficient information upon which to base a diagnosis is obtained by the learner, he makes his choice of diagnosis and the instructional program gives appropriate feedback. In the event of an incorrect choice, feedback directs the learner's thinking regarding subsequent choices towards the correct diagnosis. Two cases require differentiating three diagnoses in order of suspicion, and four cases require only the primary diagnosis.

A pretest portion consists of two cases wherein the learner develops the patient history, physical examination, and laboratory findings by questioning the computer program, as if it were the patient or the laboratory. The choice of differential diagnosis is stored in the computer's memory. Later, in the post-test, the learner may alter this differential diagnosis after completing the intervening course of instruction. The first part of the instructional material reviews normal findings, a systematic approach toward oral examination, and the appearance of benign and malignant oral lesions. The second part of the course of instruction consists of four cases using lesions which have teaching value regarding salient points in oral cancer detection. The learner has the option to take additional material in three subjects:

1. Oral Biopsy and Referral for Cancer Treatment.
2. Oral Exfoliative Cytology.
3. Statistics Regarding Oral Cancer.

The course requires two and one-half to four and one-half hours to complete.

This simulation of office practice is based on a 125-item listing of the parts of a history, physical exam, and laboratory tests to which code numbers have been assigned. In a similar fashion, disease entities and categories were number coded. These came to a total of 115 entries. The user selects his requests for information in any order he deems necessary. When the diagnosis choice is made, further information cannot be obtained from the history, physical or laboratory data.

The course authors realized that use of a listing would structure the responses by the user and that a free-response mode would have been more ideal, especially in a diagnostic situation. In the near future, it is possible that this program will be revised to accommodate free response; however, as an initial attempt at CAI course writing the authors felt that use of a listing permitted simpler programming than if freely structured requests for information were used, and still satisfied the course intent.

As an illustration, I will simulate one of the case studies that is given in the course. I will give the information that the user receives upon request.

To begin a case study, the user types 099. (A booklet listing the possible areas of request is located next to each terminal.) He gets a feedback from the computer which says, "Chief Complaint: Look at Figure ____ ." The comment is, "I keep biting this sore on my tongue."

The user then looks at the book of listings. He chooses 100, which asks what the present illness is. The computer responds with, "Patient states that the lesion area was bitten two months ago while eating. She says that she continually irritates it and it is getting larger."

The user then asks if it is painful by typing 103. The computer responds with, "Painful at times, especially when bitten." The user then wishes to ask, "Has there been a weight change?" He types in 105. The computer responds, "None."

The user then asks for a physical examination, specifically of the tongue, and types in the appropriate number, 418. The computer responds with, "Left lateral border of tongue, soft, movable, exophytic mass, 2 x 1.5 x 1 cm., easily bleeding on palpation."

The user now would like information regarding the lymph nodes, and types 427. His reply from the computer: "Left submandibular lumph nodes small, movable, and non-tender." The user then asks for a general history and types 200. The computer responds with, "This 29-year-old Negro patient states that she is enjoying good health, and denies any severe disease or injury in the past. She has had two uneventful pregnancies and deliveries. T and A at age 4, broken arm at age 3. Hay fever in summer. No sensitivities to medicine. Has chronic sinusitis."

Now the user asks for an exfoliative cytology, and types the corresponding number. The computer responds with, "Yes, but the specimen will be quite bloody, and cytological examination will be less than optimal."

The user, in that case, asks for a surgical incisional biopsy, which is 731. The computer responds again, "No, the lesion is small enough that it should be excised with a good margin of normal tissue. A pathology report will not be given. Base your diagnoses on history and appearance."

At this point, the user feels he has enough information and he types in 999, signifying he is ready to make a diagnosis. The user looks at the list, decides the proper diagnosis is squamous cell carcinoma, and types the corresponding number, 4121. The computer responds with, "You chose: Squamous cell carcinoma. Your index of suspicion for cancer is to be commended, but several factors, admittedly tenuous, also suggest other possibilities. In differentiating this from tumor we may use the following parameters:

1. Its texture: soft.
2. Its lack of deep fixation to the tongue (that is, its mobility).
3. An explicable origin in trauma, and continued progression by the same mechanism.

A biopsy is indicated, however. Select another category."

The user then feels that it might be focal acute inflammation and types 1120. The computer responds with, "You chose: Focal acute inflammation. Yes, now which one is it? Try again."

The user now becomes more specific and chooses pyogenic granuloma. The computer responds with, "You chose: Pyogenic granuloma. Yes, of course. This was a difficult diagnosis because this lesion is of unknown etiology, but is thought to be of low-grade infectious and traumatic origin. The histologic picture is that of endothelial hyperplasia. Its differentiation from tumor is difficult due to its exuberant growth characteristics. Therefore, it must be removed for pathologic examination, and, because tumor is usually in the differential diagnosis, it must be removed without delay."

Feedback-response to the selected diagnosis will give the reasons for or against the correctness of choice together with a clue to the proper diagnosis. It is this portion of the course which is most popular with the users.

It should be noted that this course was directed primarily to the practicing dentist or physician. If the course material were primarily designed for student use, rather than for the continuing education of health practitioners, it would have been a relatively simple matter to program the information-gathering section (the history, physical and laboratory data) to store the requests from the learner. Then, at the time of diagnosis selection, the program would indicate that insufficient information had been obtained, or that a different sequence of information gathering might have been more efficient.

This form of presentation is believed to be perhaps the best available method for training future practitioners in the art of history-taking, short of a one-to-one, teacher-student team for patient evaluation. Working in a team, however, still does not guarantee every student adequate exposure to complicated or unusual cases. The computer memory is an every-handy repository for this type of material.

Now that I have given you a rough sketch of the history of CAI at Ohio State, I would like to give you some notions of what we, at least tentatively, envision as the role of CAI and other forms of educational technology in the Ohio State University College of Dentistry.

At present, the College of Dentistry is undertaking a major curriculum change, planned for implementation in 1972, to coincide with an increase in enrollment from 155 to 205 entering freshmen. A faculty education program to acquaint instructors with the adjunct utilization of CAI and other forms of educational technology has been planned. This program will take the form of two series of faculty seminars. One will discuss the various categories of educational technology that are realistically applicable in dentistry. Major emphasis, however, will be placed on CAI. CAI programs now available to dental students will be reviewed from the standpoint of course development.

The second series of seminars will involve those faculty members who have demonstrated an interest in utilizing CAI. Included in these sessions will be discussions of program strategy or strategies relative to specific course objectives, and of programming languages (especially COURSEWRITER III, Version II).

Furthermore, particular assistance in program preparation will be given to each interested faculty member. Five courses will be written by five departments within the College of Dentistry as demonstration programs.

As a result of this experience, a decision will be made by the faculty whether or not to develop in the Dental College a learning laboratory based on CAI. This laboratory will develop and function in coordination with the revised dental curriculum.

If accepted, CAI will become a tool for student guidance, counseling, and tutoring during his dental training. Moreover, simulation programming for unusual or complicated patient-management situations should provide a much needed variety of experiences for dental students. Such simulations will provide valuable assistance in acquiring the skills of history-taking, diagnostic decision-making and management decisions.

The problems of increased enrollment, of a higher student-faculty ratio, and the lessened chance for each student to receive a full measure of clinical experience, certainly warrant the development of simulated clinical experiences. They also warrant the use of CAI as a means for students' self-evaluation of their studies, for drill and practice, and as a source of evaluation information upon which to base course content, student counseling and tutoring by faculty members.

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LINEAR PROGRAMMING AND COMPREHENSIVE PATIENT CARE IN CLINICAL DENTAL EDUCATION AT THE UNIVERSITY OF NORTH CAROLINA

Clifton E. Crandell
University of North Carolina

Linear programming is a mathematical technique which can be used for determining optimum allocation of resources, such as capital, raw materials, manpower, plant, or other facilities. An objective might be to minimize cost; it might be to maximize time in a teaching situation. Of course, there have to be alternate choices that can be made or else there is no linear programming problem.

Linear programming is only a small part of the field of operations research, which is, by and large, a computer-based set of techniques that have been used extensively by the Department of Defense and by such industries as the petroleum industry to find solutions to problems that have a very large number of variables. These techniques have seldom been used in education and are just now becoming of interest in health care delivery systems. Until World War II these techniques remained relatively undeveloped. Computer technology has made it possible to develop this field to its present level of sophistication.

The objectives of this project at the University of North Carolina have been three-fold. In the first place, we wanted to demonstrate the merits of linear programming for the optimum allocation, scheduling, and utilization of teaching staff and physical facilities in clinical dental education. Secondly, we wanted to demonstrate a practical application—remember we said that you had to have some variables and choices you could make—by introducing the total patient care concept and studying what effect this had on the model. Thirdly, we wanted to make these data available to other schools, and that is why I am here today.

The introduction of the concept of total patient care will provide students, we hope, with a clinical experience in dental school which will closely simulate the conditions to be encountered in private practice after graduation. Linear programming techniques will permit us to realize a system of clinical dental education in which students provide comprehensive care to patients, as opposed to the traditional point and block systems of clinical teaching which provide fragmented care.

Specifically, our pilot program at the University of North Carolina has sought to demonstrate that this concept can be introduced without lowering the quality of instruction or increasing the cost of clinical teaching. We hope to identify some parameters that will enable us to improve dental teaching and actually spend less money. Both of these are worthy objectives that will benefit both the student and the faculty, as well as the population that we serve.

In carrying out this project over the past three years, work has proceeded along several lines. First, we analyzed the clinical teaching situation, using a systems approach, and identified the factors that are significantly related to the effectiveness and efficiency of clinical instruction. Included was an analysis of technique procedures that students are required to accomplish, the classification of students in terms of ability, the time required with reference to these procedures, the rate of utilization of equipment and physical facilities, the rate of utilization of instructors' services, and a classification of patients in terms of the complexity of their dental needs.

Secondly, we assumed that the relationships between these factors were linear. I should add, at this point, that there are also nonlinear programming techniques. Nevertheless, we assumed for our case that the relationships are linear. We simulated these factors conceptually in a mathematical model, and the information was fed into the computer as representing the clinical situation.

We have identified variables which we feel might represent the dental clinic. The problem for the computer was to determine which set of conditions would give us the most efficient operation of the dental clinic. Once we are satisfied that our mathematical model best represents the clinical situation, and this is not an easy point to reach, we will then experiment with changes in the operation of the clinic within the computer without making any changes in the real-world or clinical situation. This is one of the chief advantages of the technique. Once you get a satisfactory model, the cost of experimentation is very little, certainly much less than building a new building or hiring an entirely new faculty.

LINEAR PROGRAMMING: FINDING THE OPTIMUM WITHIN THE FEASIBLE

With thanks to IBM, I would like to cite a very simple example of linear programming and how it can be used.

Let us consider, in this example, a small machine shop which manufactures a standard model and a deluxe model of an unspecified product. Each standard model of the product requires four hours of grinding and two hours of polishing, while each deluxe model requires two hours of grinding and five hours of polishing. The manufacturer has two grinders and three polishers. Therefore, in the 40-hour week, he has 80 hours of grinding capacity and 120 hours of polishing capacity. He makes a profit of $3.00 on each standard model and $4.00 on each deluxe model.

The question might be, how should the manufacturer allocate his production capacity to achieve the most profit? The first step is to convert this problem statement into mathematical form. We let the symbol "S" stand for the number of standard models manufactured in a week, a convenient time period to work in, and let "D" represent the weekly number of deluxe models manufactured. By their definitions, "S" and "D" are greater than or equal to zero. The profit for making "S" standard models and "D" deluxe models in a week can be expressed as

$$\text{profit} = (3S + 4D) \text{ dollars.}$$

Now if five standard models, $S=5$, and seven deluxe models, $D=7$, are built in a week,

$$\text{profit} = 3x5 + 4x7 = \$43.00.$$

If the manufacturer could make 25 standard models and 20 deluxe models, the profit would be $155.00.

How can we express the restrictions on machine capacity? The manufacturer of each standard model uses four hours of grinding time. Making "S" standard models therefore requires 4S hours. Similarly, the manufacturer of "D" deluxe models uses 2D hours since the manufacture of one deluxe model uses two hours of grinding time. The total number of hours of grinding capacity used in a week is 4S plus 2D. Since we have already said that 80 hours of grinding time were available, we might be tempted to write

$$4S + 2D = 80 \text{ hours.}$$

This formula would be incorrect because we have no assurance at this point that the greatest profit will result by using all the grinding time. All we know is that the total grinding time must not exceed 80. Conveniently, this can be expressed as

$$4S + 2D \leqslant 80 \text{ hours.}$$

In the same manner, we arrive at the limitation of polisher capacity

$$2S + 5D \leqslant 120 \text{ hours.}$$

Since a higher profit per unit can be made on deluxe models, one might expect that the optimum policy would be to make as many deluxe models as possible and to forget about the standard models. This may not be correct. Let us calculate how many deluxe models alone could be made and record corresponding profits for future reference. The limitation on grinder time provides that two times the number of deluxe models must not exceed 80 and the limitation on polisher time provides that five times the number of deluxe models must not exceed 120. The grinder capacity permits 40 deluxe models to be made; polisher capacity permits no more than 24 to be made. Therefore, 24 is the maximum number of deluxe models that could be made even though this policy would only consume 48 hours of the grinder time out of the 80 that are available. The profit with this policy then would be $96.00, since there is a $4.00 profit on each of the 24 deluxe models.

Similarly, if the policy of producing just standard models is chosen, only 20 models could be produced in a week because of the limitation imposed by grinder capacity. With this policy, profits would be $60.00 and only 40 of the 120 hours of polisher capacity would be used. Although the first policy results in a higher profit, these are not the only two alternatives.

Many other policies might be chosen in which some mixture of standard and deluxe models were produced. For each mixture of model types proposed, it would have to be determined whether grinder and polisher capacities were sufficient and, if so, what the profit would be. Eventually, the policy or policies returning the greatest profit would be found by considering, in turn, each possible policy. Linear programming provides the framework for solving the manufacturer's problem of choosing a policy that will maximize profits, but the computer assists greatly by assuming the burden of calculation.

Conceptually, the solution process can be appreciated more easily with the aid of a graph. Figure 1 shows an area bounded by two axes. The vertical axis represents "S," or the number of standard models produced. The horizontal axis represents "D," or deluxe models produced. Any point placed on the graph would represent one week's production of the two types of models. Figure 1 also shows the constraint imposed by grinder capacity, which has already been expressed as

$$4S + 2D \leqslant 80 \text{ hours.}$$

Any point below the line represents a specific combination of "S" and "D" which does not exceed grinder capacity. Points on the line represent combinations which would use all grinder capacity, ranging from 20 standard and no deluxe models to 40 deluxe and no standard models.

Figure 2 shows the constraint on polishing capacity. As before, points below or on the second line represent combinations which are within or no greater than polishing capacity. These two constraints, together with the horizontal and vertical axes, produce an area of possible or feasible combinations of "S" and "D" which do not exceed the capacities of either type of machine. This area, shown cross-hatched in Figure 2, is called the feasible region. Also included in the region are combinations which fall on the boundaries.

The next thing to do is to take profits into account by referring to our expression for profit of 3S plus 4D dollars. While it can be readily seen that any point in the feasible region except the origin (S=0, D=0) will result in a profit, we are looking for the point or points that represent the policy with the greatest profit. One way to approach this is by assigning the profit for any *known* feasible solution, such as \$60.00 from the earlier policy of producing all standard models (S=20, D=0), to the right-hand side of our profit equation. This profit equation, $3S + 4D = \$60.00$, defines the dashed line shown in Figure 3. Substituting any other value for profit into the profit

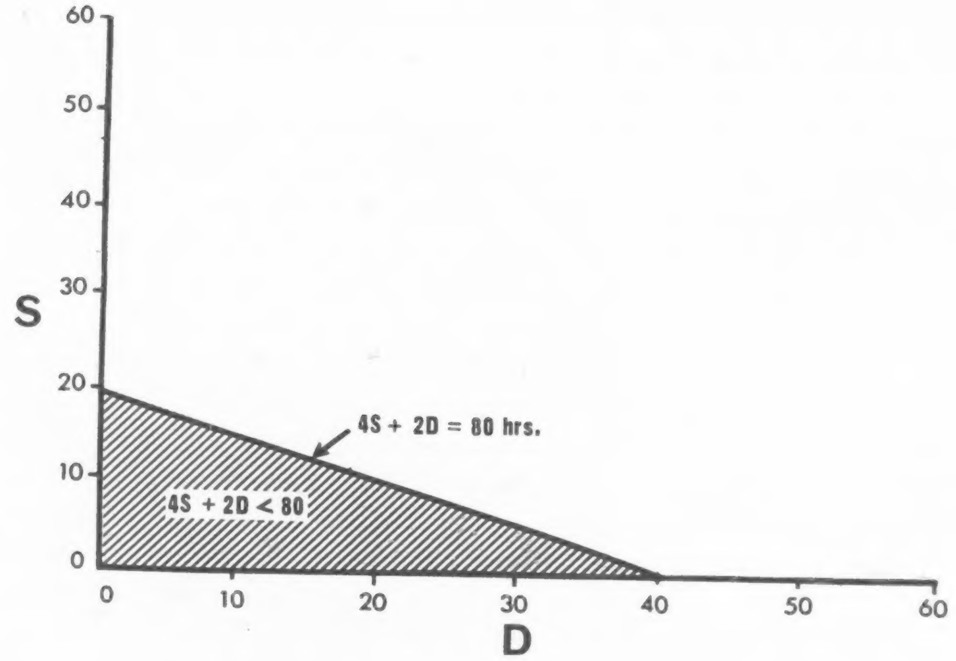

Figure 1. Solution space with grinding constraint.

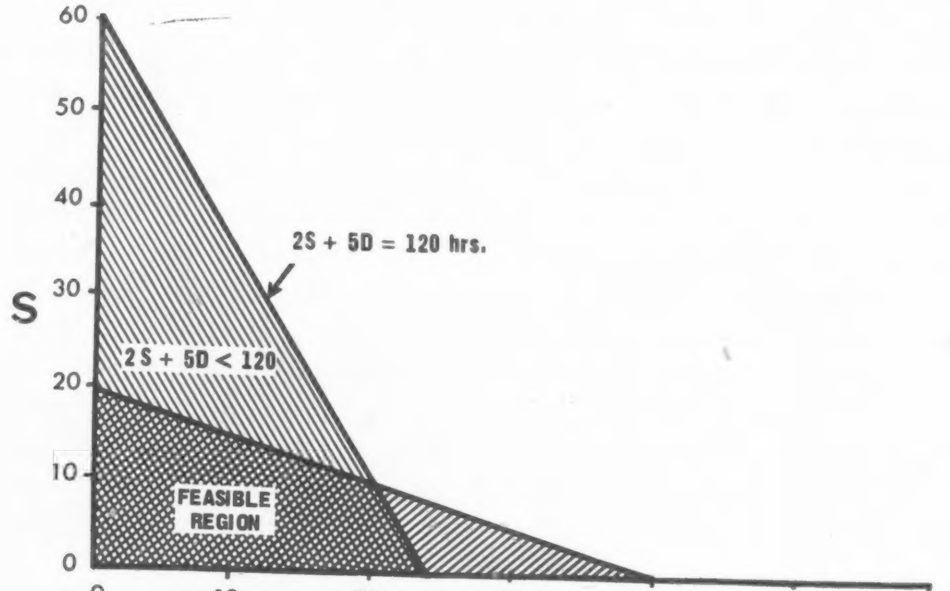

Figure 2. Solution space with feasible region defined by grinding and polishing constraints.

equation (3S + 4D = profit) would define another specific line parallel to this one. Remember our objective is to find the greatest profit. Geometrically, we do this by finding that profit line which lies as far away as possible from the origin of the graph and still touches the feasible region. For our example, we can draw by inspection the second dashed line (parallel to the first) shown in Figure 4 and then calculate the values for "D" and "S" for the point of intersection of this profit line and the feasible region. This point of intersection tells us how many standard and deluxe models to make in a week. Substituting these values into our profit equation tells us what the maximum profit will be. The optimum solution of this problem shows that we can make $110.00 per week based on the manufacture of 10 standard models and 20 deluxe models, as compared to the $96.00 possible by producing deluxe models only.

Now extrapolate and consider the dental clinic model, which has many more equations than you have seen. Each equation contains an expression of the limitations of junior students, senior students, faculty, various clinical specialties, dental units, various clinical teaching areas, and the approximately 75 procedures that are performed in our dental clinic, plus, of course, the time constraints within which they are performed. If you can visualize such a set of equations, you will have a fairly clear conception of the linear programming model that we have been working with for the past three years.

Obviously, when one gets more than five or six lines on a graph, it becomes very difficult to tell exactly what is going on. A problem containing more than three simultaneous equations isn't easy. This is why the computer is essential to this kind of research. I think you might be impressed with the efficiency with which the machine solves the dental clinic problem. An early run of this problem included 73 such equations, with a total of 113 variables. The entire operation required an investment of computer time of one minute and 49 seconds at a cost of $10.94.

That is only one part of the total problem. We have never successfully run the complete problem for a number of reasons. Once we ran out of disk space. On another occasion, our job was cut off by a time limit of 99 minutes. At $350 per hour, you can see why we do not play around with this unless we mean business. Although we still have not run the full problem, we can, I think, make the statement that linear programming has been demonstrated to be a feasible management technique

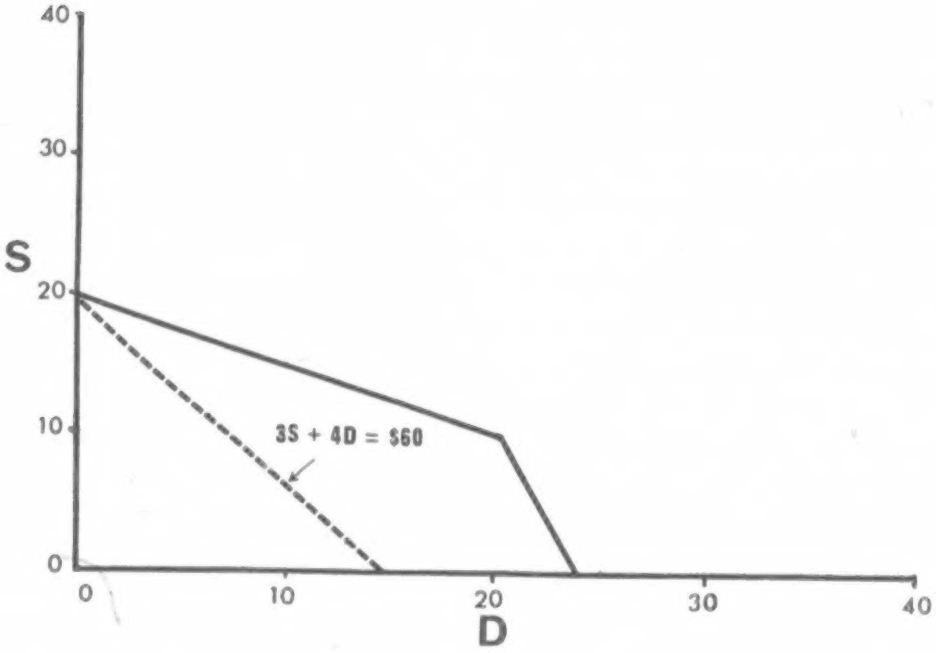

Figure 3. Feasible region (enlarged scale) as defined in Figure 2, with profit equation.

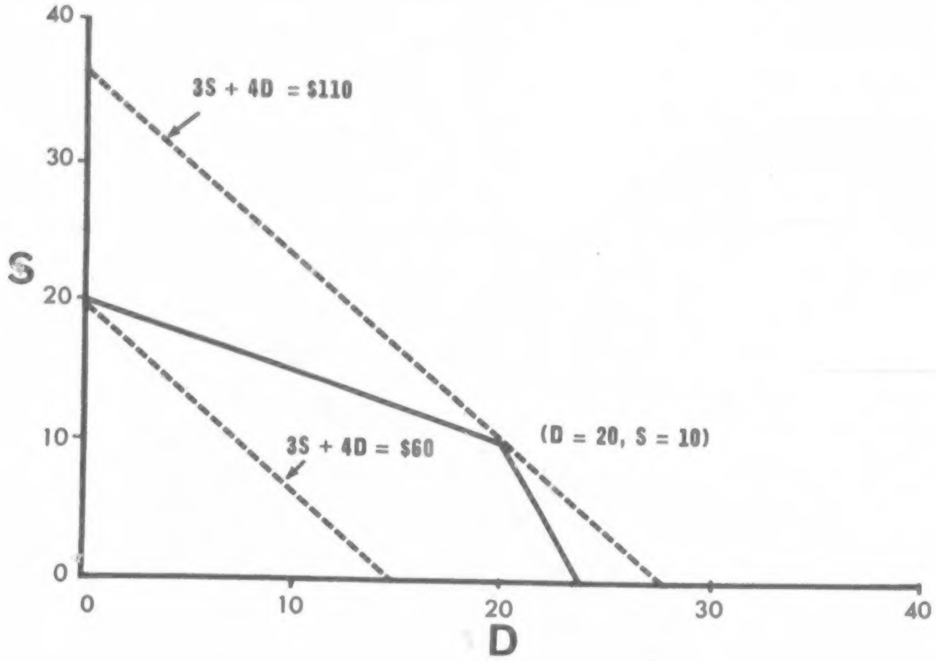

Figure 4. Feasible region with optimal solution.

to use in clinical dental education. If it were not feasible, the machine would have said, "There is no feasible solution."

LINEAR PROGRAMMING AND TOTAL PATIENT CARE

The other part of this story is total patient care. Earlier I told you that our project is a practical application of the linear programming problem. The clinical phase of this work was initiated on a pilot basis in June 1968. It was aimed at performing several functions, the first of which was to provide an additional data base for our linear programming model. Most of the data in the model now is the result of guesswork. Secondly, we wanted to introduce automatic data processing to the students, the faculty, and our staff. Thirdly, we wanted to introduce a new curriculum, based on the comprehensive care concept, which we did in the fall of 1969.

This phase of the project—total patient care—has involved five junior students to whom patients have been assigned manually because a computer program designed to match patients to students is not yet fully operational. The five students were selected by dividing the junior class into five academic levels and choosing one student at random from each level. Five more juniors joined the total patient care (TPC) group in the fall of 1969. Patients were selected who would provide a balanced clinical experience equal to or greater than the usual clinical requirements in the various departments. Progress of these students has been monitored constantly, and monthly reports have been provided to department chairmen and administrators. A year-end report was developed in May 1969 and is used to compare these students with the rest of the class, which serves as a control group.

Because of the nature of the program, the TPC group did about 15 times as much preventive dentistry as the other students. Their experience in pedodontics is not included because there is not enough information. In oral diagnosis, the control group made more radiographs but did less charting. In endodontics, the control group did an average of 3.6 root canals as compared to 2.8 for the TPC group; in periodontics, the controls did fewer major cases, but more minor cases.

In fixed prosthodontics, there is very little difference between the two groups. In removable prosthodontics, the TPC group did only about half as much. In operative dentistry, which is perhaps the most important and certainly occupies a large portion of the curriculum, the TPC group came out in front in gold foils, amalgams, inlays and total, while the controls accomplished more in the silicate/resin area. Of course, these data do not show the total clinical activity of either group. The TPC group participated in only two block assignments—surgery and DAU. On the other hand, the controls did preventive work for only one patient while the TPC group did this for every patient.

I leave it to you to interpret this data as you wish. We are evaluating the project in several ways, particularly by using the data gathered concerning the measurement of attitudes toward total patient care. Clinical ability and interpersonal relationships have not been evaluated as yet because there is insufficient information. Some of the measures that we plan to use, and are using, include the quality, quantity, and speed of clinical procedures, and scores on board examinations, both national and state, comparing the TPC and the control groups.

We also plan a computer-based, interactive, diagnostic simulation as an evaluation instrument. This scheme, we think, will be the crux of the evaluation because we are trying to train better diagnosticians.

STUDENT AND INSTRUCTOR WAITING TIME

There is another phase of Operations Research that is pertinent to this discussion. Although queuing and work loading studies have not been integral parts of the project thus far, they are a logical extension thereof and I personally feel that they have a greater potential than linear programming. We have made limited pilot efforts by timing contacts between instructors and students in the clinic by quarter hours, as well as by monitoring down time, i.e., that time when an instructor has no demands for his services. Simultaneously, the length of the queue behind the instructor was recorded.

As far as I have learned, there is no efficient, satisfactory method for acquiring this data at the moment, and therefore we are going to have to develop a method before we can proceed. We hope this kind of study will reveal patterns of instruction in clinical modes that would permit more efficient scheduling of faculty, students, and physical facilities. The only thing I can say at this time is that a student who is waiting for an instructor learns very little. And it is equally apparent to me that the instructor who is waiting for a student to demand his services does very little teaching. Both of these situations exist to a large extent in clinical dentistry. A study of laboratory teaching will probably be even more fruitful since there are far fewer variables to worry about.

EQUIPMENT

Now I would like to mention the equipment with which we have been working. In the dental building there are four units of equipment, all rented from IBM. There is a 1051 control unit which controls a 1052 printer keyboard and 1056 card reader. The fourth unit is an 029 key punch, which operates as a separate unit. The first three units form what is called a 1050 data communication terminal. In earlier sessions of this conference, I noticed that a number of speakers, in disucssing CAI, mentioned using this kind of terminal equipment. Ours is in the medium price range; less expensive and more expensive equipment are both available. The terminal is connected to the IBM 360 Model 75 computer at the Triangle Universities Computation Center, which is in the Research Triangle Park, 12 miles away.

PROBLEMS

You might also be interested in knowing some of the problems we have had. If I can enumerate some of them, and thereby save you from the same pitfalls, it will be worthwhile. Our chief problem has been time. The TPC students have pointed out to me that it takes more of their time to run a comprehensive care program than it does if they simply show up for block assignments and work on whoever is there. In other words, they are actively engaged in the mangement of a practice, and this takes time. Of course, the series of diagnostic procedures that they are required to do is considerably greater than that for the control group. In some ways their activities are more rigidly controlled. They have less freedom to decide when and for whom they work. That is, they have to satisfy the patients' demands and these are more stringent than block assignments.

The TPC students feel that with their experience under the new system they are better prepared to enter private practice than they would have been otherwise. However, spending so much time on diagnostic and management procedures, they have had less time to spend on restorative procedures. This places them at some disadvantage, compared to the control group, in equaling the minimum requirements. I am afraid that on this point there has been some intimidation on the part of the faculty.

Even though he does not have formal requirements in the TPC group, still a student had better do x number of procedures.

Time has been a factor for me personally. I wish I could have spent more time counseling these students. It is my guess at this point that ten students is the absolute maximum that any one faculty member can supervise in a comprehensive program. Those of you who are responsible for hiring and firing and getting the budget to pay salaries will have to find more money and more faculty if you are considering comprehensive care.

Another problem has been the maintenance of two record-keeping systems. This was necessary because the computer program was not ready. This was the result of a bad guess on my part and I will take full responsibility for it. We hoped that this program could be written in a period of three months. Eighteen months later, we are still writing. We hope we will not be more than two years off schedule.

Yet another problem is keeping patients. We have had very good fortune, but there have been a number of drop-outs, as in private practice. Some do not like the program after they get into it and they leave.

A further problem has been predicting, with a satisfactory degree of accuracy, the clinical needs of these patients. We do this on the basis of bite-wing radiographs, a Panorex film, and a cursory clinical examination. The major problem is in operative dentistry. As you know, in preparing a cavity, many times you cannot tell what kind of filling material must be used in that tooth until you have removed all the decay and unsupported enamel rods. What starts out to be a Class I amalgam may end up as a Class II inlay.

In addition to that, our operative department has a clinical grade based on quality and quantity, and while I might be able to guess fairly accurately how many surfaces are going to be required to restore a tooth, there is no way that I could tell what kind of grade the student is going to get on the restoration. Nevertheless, in scheduling patients we are expected to take work in progress, including grades, into account in making our assignments.

Integration of the total faculty into the program is also a major objective of our project at UNC. The Curriculum Committee has decided that beginning in the summer of 1970, the screening of patients will be done by the faculty. All cursory examinations, selecting the patient, planning treatments, and counseling students, will be shared across the board with the entire staff. It will not be a function of just the oral diagnosis or the screening area staff.

So much has been said about problems in keeping records for a computer-based system that I will simply say that we have those problems too. Those who are uninitiated should know that the handling of exceptions occupies about 90 percent of the efforts of data-processing people. There are some rough days ahead for you if you think the computer is going to eliminate your problems.

In closing, I cannot pass up this opportunity to offer some philosophy. You have heard reports here of people using computers for grading, record-keeping, instruction, and many other functions. If you have any administrative problems in these areas, do not expect the computer to solve them. More likely, the computer will compound them. Similarly, do not expect a computer to save you any money. It is a machine that crunches numbers; by itself it will not teach, it will not grade students, and it will not keep records. But it can *help* you do these things for a price—and it is a pretty steep price.

Finally, I would like to say that I heartily support CAI and all the other computer uses that are being discussed here, but I am personally convinced that operations research techniques offer the greatest potential in planning to meet the challenge posed by the health care demands of the seventies and eighties.

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STUDENT EVALUATION IN CLINICAL COURSEWORK

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I would like to start by speaking about clinical evaluation and then about a method of keeping track of the student's progress. At USC the primary problem seems to be relating quality of clinical operation with quantity. Some schools have a requirement system, some allocate points for specific job operations, and some do both. We are currently able to keep track of *quality,* in terms of grade point average, *quantity,* or the amount of clinical experience and, in addition, have developed a third measure which combines quality and quantity in what we feel is an objective overall measure of clinical performance.

Quality of clinical performance is graded on a four-point scale. On any particular job operation, we suggest grading by deletion. Take, for example, an inlay which could be given a grade from 0.0 to 4.0. The job might be broken down into steps which are scored separately and totalled to arrive at a grade. Forty points might be assigned to the job as follows: the preparation may be worth ten points; the impression, five; the wax pattern, another five; and so on to completion, which is worth perhaps another ten points. If you want to be explicit, you can break down each and every item into line angles, flares, etc. At the end of the operation the instructor will then total the points and come up with perhaps a total of 32 out of 40 possible points for a grade of 3.2.

In order to standardize our measure of quantity we have determined the average number of hours required to perform each clinical operation. The inlay just described might take ten hours to complete on the average and would be assigned a value of ten baseline points. Baseline points for completed operations are accumulated within departments (and overall) to yield a measure of experience obtained regardless of grades.

To retain a numerical measure of both the quantity and grade of a student's work, while permitting both a requirement system and a total patient care system to operate, we developed what we call a translated baseline point system. Table I demonstrates how baseline points, or hours if you will, are combined nonlinearly with grades to yield translated baseline points.

Table I

Example of Conversion of Baseline Points to Translated Baseline Points

Letter Grade	Operation Grade	Baseline Points	Multiplication Factor	Translated Baseline Points
A	4.00	10	3.000	30
B	3.00	10	2.625	26
C	2.00	10	2.000	20
D	1.00	10	1.125	11
F	0.00	10	0.000	0

Assuming that a student completes a job worth ten baseline points, if he receives a 3.0 grade, or what you might call a *B*, he would get 2.6 times as many translated baseline points as baseline points for the operation. Should he receive an *A*, or grade of 4.0, his multiplication factor would be 3.0 and he would get three times as many translated baseline points. These multipliers were selected by a faculty committee at the school to weight quantity of work slightly more heavily once the minimum grade of *C* is exceeded. The rationale is to ensure that even the top students receive a reasonable amount of experience in each department. The multipliers in Table I are based on the following equation, in which Y is the multiplication factor and X is the grade for the operation on a 4.0 scale:

$$Y = \frac{10\,(X) - (X)^2}{8}$$

We keep track of all students throughout their clinical experience. Figure 1 shows the first of the three sections of the student's copy of his progress report which he receives monthly.

One of the reasons we furnish monthly progress reports is to minimize the anxiety and fear that students feel about evaluation as documented by the Guild Report.* Slow feedback of grades and class standing was cited as one of the main causes of their concern. Except for occasional computer delays, we get reports to the student fairly rapidly and we maintain, at all times, the reference point of his overall grade average. We have his current standing—that is, current from the last print-out to the present one—and we have the previous year's.

In order to understand Figure 1, look at *F. PROS* (Fixed Prosthodontics) in the department column. Here the student has a 2.70 grade point average and ranks fiftieth in the class on the basis of quantity. Notice, however, that in the next two columns he has 612 baseline points, and is ranked eleventh in class on the basis of quantity of work done. In the fifth and sixth columns we find that he has acquired 1523 translated baseline points resulting in a rank of twelfth in the class in this department—a composite of the other two rankings.

Each department chairman, acting autonomously and at his discretion, decides what the minimum translated baseline point requirements will be for the purpose of determining final course grades.

The last column, *Percent Complete,* shows the student just how close he is to completion in any one department at any time, according to the year's total translated baseline point requirements as determined by the department chairman.

Work in progress (as shown in Figure 2) is listed in order of starting date so that we can locate a particular case according to starting date. We have the patient's name, the patient's number, and the serial number in our input form. (I will explain later how we get the input into the computer.) We have the number of baseline points that the item is worth, the tooth number, and the job code. Each and every dental operation is coded.

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*Guild, R.E. Questionnaire studies at three schools of dentistry. *Journal of Dental Education,* 1966, 30, 344-353.

STUDENT PROGRESS REPORT

STUD #	STUDENT NAME	CLASS
011	DOE, JOHN	SENIOR

	Grade AV	Grade Class Rnk	Grade Percntle	Base Line Points	BL PTS Class Rnk	BL PTS Percntle	TR BL Points	TR BL PT Class Rnk	TR BL PT Percntle	Work In Prog	Percent Complete
CURRENT	2.71	58	31	2586	12	85	6306	19	77		
Department											
D & TP	2.57	52		154	17		363	25			182
ENDO	4.00	1		45	81		135	76		10	64
F. PROS	2.70	50		612	11		1523	12			305
OPER	2.36	65		676	59		1512	62		83	100
PEDO	2.83	56		113	55		284	60		1	118
PERIO	2.63	78		136	70		328	72			121
PROS	3.11	35		403	9		1080	9		10	240
RPP	2.96	60		102	52		264	56			110
HOSP S	3.00	2		30	3		78	4			108
ORAL D	3.00	54		162	23		425	29			177
ORAL S	2.00	66		123	65		246	71			103
D A U P	2.20	42		30	1		64	42			107

Figure 1. Sample of monthly progress report provided each dental student summarizing the clinical work he has completed by department.

WORK IN PROGRESS

START INSTRUCTOR	DEPT NAME	DEPT CODE	JOB CODE	TOOTH NUMBER	BASE LINE	SERIAL NUMBER	PATIENT NUMBER	PATIENT NAME	START DATE
VOSS, R.	OPER	D	00000009	12-00	006	279	30359	AUSTIN EVE	11-22-66
BERGER, J.	OPER	D	00000007	19-00	004	286	11426	OLIVER ROBERT	11-29-66
REDMON, R.	OPER	D	00000001	00-00	001	293	54781	REDONDO WILLIAM	01-15-67
PAYNE, K.	PEDO	E	00000007	14-00	001	295	28817	AMIRAULT GARY	01-15-67
VANDERHEIDE, J.	OPER	D	00000000	04-00	002	297	805	BLUME JOHN	01-16-67
VANDERHEIDE, J.	OPER	D	00000001	00-00	001	296	805	BLUME JOHN	01-16-67
VOSS, R.	OPER	D	00000026	21-00	020	15528	805	BLUME JOHN	02-07-67
VOSS, R.	OPER	D	00000023	14-00	020	15530	34574	DIGNAM BURKE	02-07-67
BEVERIDGE, E.	OPER	D	00000021	08-00	001	15548	31788	EDWARDS CAROLYN	02-20-67
VOSS, R.	OPER	D	00000026	13-00	020	18044	30359	AUSTIN EVE	03-10-67
RICHARDSON, G.	PROS	G	00000028	00-00	010	18047	30507	SELIGER BERNICE	03-14-67
KITTEL, J.	OPER	D	00000002	15-00	002	22102	13673	NICHOLS ANITA	03-17-67
KITTEL, J.	OPER	D	00000002	14-00	002	22103	13673	NICHOLS ANITA	03-17-67
KHEDARI, A.	OPER	D	00000003	04-00	003	22110	13673	NICHOLS ANITA	04-05-67
VOSS, R.	OPER	D	00000020	03-00	001	29685	34574	DIGNAM BURKE	05-26-67

Figure 2. Continuation of monthly progress report provided each dental student showing the clinical work he has in progress according to date treatment was started.

The work completed is printed out by department as shown in Figure 3. We are no longer concerned with the starting date because the job is completed. We are now concerned with the items that the student has finished, with his grades, the points he has received, and so forth. These are the items that are reflected in the top line of Figure 1 to give him his overall average and ranking.

Notice the *Paymnt Diff* column in Figure 3. We have set up a system whereby the computer checks to see if the proper payment for any operation is made. An interesting sidelight here is that since going on this system our income in crown and bridge alone jumped $10,000 a year over our projected average, because of tighter control. Without the computer to cross-check, billing mistakes would go undetected. For example, a student might do a five unit bridge, write it up as a three unit bridge for the cashier, who may be too busy to check, and even though the instructor has signed off for a five unit bridge, we don't get paid for two of those units. Under the new system, if the student writes it as a five unit bridge and the instructor verifies it, we are going to get paid for that five unit bridge. If a different fee comes in, it shows up here in the payment difference column. For those concerned with clinic budget and clinic income, here is an easy way to increase revenues.

Figure 4 is the Department Status Report which each department head receives. It shows all the work done in that department, by student.

The computer input documents which I referred to earlier consist of a manifold form in five differently colored copies made up like a department store salesbook. The top white original is the "start" sheet which the student fills out and has the patient sign. (This form helps avoid those law suits in which the patient says, "I didn't know what you were doing—you were standing behind me and I couldn't see.") Once the "start" sheet is signed, the student then calls the instructor over to make a start check, and he is off and running. The instructor then tears out the "start" slip, puts it in his pocket, and sends his coat to the laundry. This happens! The point I am making here is that no method of input is any good unless you get people's cooperation. In our case, it was up to the departmental secretaries to go through the pockets of the instructors' gowns before they were sent to the laundry. The start check is working

WORK COMPLETED

PATIENT NAME	Dept Name	Dept Code	Job Code	Tooth Number	Base Line	Grade	Serial Number	Patient Number	Paymnt Amt	Paymnt Diff	Compltion Date	Cmpl Inst Name
Poulain Kristi	D & TP	A	00000001	FM-00	003	3.5	14060	44207	4		02-15-67	Finke, W.
Williams Josephi	D & TP	A	00000006	00-00	010	2.0	325	70465			01-26-67	Beveridge, E.
Johnson Carol	D & TP	A	00000001	00-00	003	2.0	17473	1463	4		05-09-67	Finke, W.
Bradford Alma	D & TP	A	00000001	FM-00	003	3.0	17455	1503	4		04-27-67	Finke, W.
Orozoco Eliseo	D & TP	A	00000006	00-00	019	2.0	19652	30006			03-14-67	Dr Finae
Cheung Chun	Endo	B	00000001	29-00	010	3.9	312	32054	25		01-12-67	Meehan, R.
Witthan Warren	F. Pros	C	011	03-00	012	3.4	17474	62108	25	1	03-14-67	Dr Aldrich
Ireland Elded	F. Pros	C	051	20-00	012	3.0	14057	4154	26		03-16-67	Fissman, H.
Cheung Chun	F. Pros	C	051	29-00	012	3.0	311	32054	26		01-12-67	Ehrlich, P.
Flores Aureliano	Oper	D	00000009	04-00	006	2.1	14059	9997	10		03-02-67	Vanuerheide, J.
Flores Aureliano	Oper	D	00000009	04-00	006	3.0	305	9997	10		01-06-67	Eidson, R.
Flores Aureliano	Oper.	D	00000003	18-00	003	2.8	301	9997	5		01-03-67	Eidson, R.
Gonzales Aurora	Oper	D	00000000	29-00	002	3.4	17453	20201	2		02-20-67	Redmon, R.
Poulain Kristi	Oper	D	00000002	30-00	002	3.2	17457	44207	4		05-16-67	Berger, J.
Poulain Kristi	Oper.	D	00000000	30-00	002	2.7	17456	44207	2		05-16-67	Berger, J.
Johnson Carol	Oper	D	00000005	31-00	004	2.6	19671	1463	8		05-08-67	Redmon, R.
Poulain Kristi	Oper	D	00000002	10-00	002	3.2	26638	44207	4		05-16-67	Berger, J.
Gonzales Aurora	Oper	D	00000014	03-00	008	2.7	14051	20201	25		02-27-67	Redmon, R.

Figure 3. Continuation of monthly clinic progress report furnished each dental student showing the individual cases he has completed.

well now, but it did take some time to get people used to working with the forms.

Upon completion of the operation, the student must have the cashier validate receipt of payment on the second yellow sheet which he then takes to the instructor who signs, grades, and dates it. The instructor then removes it from the book. The data from this sheet appears in the print-out shown in Figure 3 and Figure 4. The cashier retains the fourth green copy and the patient receives his copy, the third blue one. It is very interesting that the phone calls regarding income tax we now get at year-end are few and far between. The student's fifth pink copy remains in the book as his record in case an error in key punching occurs. We tell the student he is in deep trouble if he loses one of these books. So far, we have not been plagued with that.

The only problem we found in coding our operations was in crown and bridge. There are an enormous number of combinations of restorations and types of bridges for which to provide. With the liberal number of spaces we had left on our forms, however, we found that we could keep track of these up to and including a six unit bridge.

This, then, is our method of keeping track of clinic students at USC and our method of evaluating them. We are in a trial period, at the moment, with a comprehensive patient care system. It will be modified to the extent that the junior year will use a requirement system and the senior year will be an internship year. We feel that if the patient assignment aspects are handled properly, we can surreptitiously have a requirement system within a comprehensive patient care program. By judiciously allocating patients to your students, you can be sure that they meet your basic requirement for the practice of dentistry within a total care package.

USC SCHOOL OF DENTISTRY – DEPARTMENT STATUS REPORT

DEPARTMENT - OF - OPERATIVE

SENIOR CLASS

STUDENT NUM. STUDENT NAME		AVERAGE GRADE GRADE	AVERAGE GRADE RANK	AVERAGE GRADE PERC	BASE LINE POINT POINTS	BASE LINE POINT RANK	BASE LINE POINT PERC	TRANSLATED BASE POINTS POINTS	TRANSLATED BASE POINTS RANK	TRANSLATED BASE POINTS PERC	WORK IN PROG	PERC DEP REQ
656	Current	3.44	12	88	112	88	18	315	88	18		
ROE, RICHARD	This Dept	3.49	5		32	82		90	78		82	6

WORK COMPLETED

PATIENT NAME	Dept Code	Job Code	Tooth Number	Base Line	Grade	Serial Number	Patient Number	Paymnt Amt	Paymnt Diff	Compltion Date	Cmpl Inst Name
KEMPER SHARON	D	00000018	19-00	012	3.4	112547	3651	32		08-07-69	KLEIN, J.
MACIAS MARY	D	00000002	14-00	002	3.0	136129	3832	4		08-08-69	YOSHIMURA, I.
MACIAS MARY	D	00000002	14-00	002	3.2	136128	3832	4		08-08-69	YOSHIMURA, I.
ROCHES RAYMOND	D	00000014	28-00	008	3.3	106720	8758	32		07-01-69	GARDNER, J.
ROCHES RAYMOND	D	00000014	20-00	008	4.0	111878	8758	32		07-01-69	GARDNER, J.

WORK IN PROGRESS

START INSTRUCTOR	Dept Code	Job Code	Tooth Number	Base Line	Serial Number	Patient Number	Patient Name	Start Date
VAN GEMERT, R.	D	00000002	01-00	002	75466	7667	PAZIRANDEM MOHSE	07-16-68
VAN GEMERT, R.	D	00000014	30-00	008	82676	7667	PAZIRANDEM MOHSE	07-23-68
BLAIR, F.	D	00000001	00-30	001	99315	5957	SCHNEIDER ED	10-11-68
BLAIR, F.	D	00000005	00-30	004	99314	5957	SCHNEIDER ED	10-11-68
MASSEY, G.	D	00000001	31-00	001	118676	5957	SCHNEIDER ED	02-17-69
MASSEY, G.	D	00000003	31-00	003	118677	5957	SCHNEIDER ED	02-17-69
SEILER, I.	D	00000003	13-00	003	122822	3651	KEMPER SHARON	05-09-69
HABERMAN, J.	D	00000028	28-00	020	111886	15396	ADACHI ROSE	06-02-69
OLSON, M.	D	00000014	19-00	008	111887	6109	TERAO ERNEST	06-04-69
OLSON, M.	D	00000013	18-00	006	111888	6109	TERAO ERNEST	06-04-69
LARNER, R.	D	00000003	12-00	003	111896	6109	TERAO ERNEST	06-26-69
HABERMAN, J.	D	00000014	14-00	008	111898	6109	TERAO ERNEST	06-30-69
YANASE, R.	D	00000000	22-00	002	92684	9902	TICHENOR PAMELA	07-14-69

Figure 4. Sample of department status report furnished to clinical staff summarizing work completed and work in progress by student within department.

PART 2

Reports of Discussion Groups and Project Abstracts

Part 2. REPORTS OF DISCUSSION GROUPS, and PROJECT ABSTRACTS

INTRODUCTION

On the basis of the interests and activities of conference participants, four broad areas of computer application in dental education were identified: (1) admissions and academic evaluation, (2) computer-assisted instruction, (3) dental school operations and educational administration, and (4) student evaluation in clinical coursework. Discussion groups organized to discuss the state-of-the-art of computer applications in these four areas met three times each during the conference.

Activities within the discussion group meetings were of two sorts. First, in an informal seminar atmosphere, each participant presented a summary of the work planned or in progress at his institution. Once these projects had been presented and discussed, the focus of attention was directed to the discussion of problems general to the group and to the identification of possible directions for solution. At the conclusion of the conference, the discussion group leaders reported the activities of their groups in a panel session before the entire conference. The remainder of this section contains both the reports of discussion group leaders as well as abstracts of the projects discussed during the meetings of the individual discussion groups. Reports and abstracts are organized according to area of application.

Some mention should be made of the nature and purpose of the abstracts. They are intended to provide the reader with a quick overview of the computer-based activities at a particular school. As preparation for the conference, participants were requested to develop written summaries of the computer-based dental education projects in which they were involved. The summaries served as a basis for discussion during the meeting and provided each participant with a permanent record of the activities planned or in progress at other schools. To obtain economy of length and uniformity of format, the original summaries were abstracted for inclusion in this report.

Capitalized keywords are used within the abstracts to signal areas of interest: PROJECT GOALS, IMPLEMENTATION, COMPUTER (HARDWARE) SYSTEM, PROGRAMMING LAN-

GUAGES, VOLUMES, SPECIAL RECORD FORMATS, STAFF, SPECIAL PROBLEMS and FUTURE PLANS.

Hopefully the abstracts will assist dental educators and others in identifying projects of interest. Further information about a particular project should be obtained directly from the author of the abstract. The appendix provides the addresses and telephone numbers of participants as of May 1970.

ADMISSIONS AND ACADEMIC EVALUATION

ADMISSIONS AND ACADEMIC EVALUATION

Report of Discussion Group

Harry Weisenfelder, *Chairman*
Leonard H. Kreit, *Recorder*

In our meetings we concentrated on admissions, discussing some of the current activities and unmet needs, and were fortunate in having in the group representatives of three dental schools that have already made a significant start on development of computer systems for admissions. I believe the participants were pleased to find there was a great deal of commonality in the approaches that they had taken. In all cases they are beginning their data collection with the admission procedure and will subsequently expand to clinical ratings. A further step is to collect, on a continuing basis, information on graduates to determine if the individual who is now in practice is providing patient satisfaction. In this regard, Dr. Donald Strachan described a very interesting study being done at the University of Michigan which used patients' appraisals of their treatment to determine how effective that school's education program has been in meeting the needs of the dental public.

We had a lengthy discussion on the desirability of promoting compatibility of data among schools and discussed using the term compatibility rather than uniformity. We would be happy to settle for compatibility. We decided that it would take a much larger group than our discussion group, perhaps a much larger group than is assembled here, to promote the compatibility of information systems that is needed. We hope that the present conference will provide a start in this direction. Perhaps the American Association of Dental Schools or a similar body could be of some help by providing a central clearinghouse function for existing procedures, or by calling together a group of experts to provide some guidelines and ground rules for compatibility.

A valuable suggestion was made that it would be very helpful for schools who do not yet have computer capabilities to nonetheless begin to maintain the information they are collecting in the area of admissions or student records (or the other data that they deal with continuously). If they could maintain this data in machine-readable form, it might later prove very valu-

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able, even if at present it is as simple a system as keypunching directly from existing forms and storing the information for future use in a computer-based system.

Next we came to a subject that deserves a great deal of attention—the desirability of having a central clearinghouse or application service to handle much of the routine work that is being done by all of the dental schools. One of the participants said his school is expecting costs of approximately $12,000 a year for merely transcribing certain aspects of the information provided by applicants. As the result of discussing such a service, the group developed a formal recommendation which I would like to read:

> The admissions and academic evaluation discussion group recommends that serious consideration be given to the establishment of a central service to assist dental schools in processing individual applications for admissions. It was suggested that efforts be made to develop a system that would enable an individual to submit a single set of transcripts and letters of recommendation to a central source for distribution in a uniform format to all schools to which the individual wishes to apply.

The group thought that a pilot program involving a small number of schools could be readily implemented, building on the experience of the centralized application service that is currently being utilized for medical schools by the Association of American Medical Colleges.

There were some additional suggestions on how this could be accomplished on a pilot basis using schools that are located in a center with a medical school. It might be appropriate to begin such a service at the time that potential applicants take the Dental Aptitutde Test (DAT). At the time they are completing the DAT forms they could also file permanent information to help establish a central clearinghouse for admissions information. The research potential alone is enough to warrant adoption of such a service without considering the savings in terms of time and money on the part of applicants and on the part of the schools in processing such information. There was considerable discussion of the value that this might have for the schools that are experiencing difficulty in getting either the quantity or the quality of applicants that they would like to have. Perhaps as a school approached its deadline it could report vacancies to the clearinghouse. However, it was felt that this might not work as well, perhaps, as a system whereby the individual's application materials might be used to indicate whether he was good potential for certain categories of schools, either by virtue of his location or other criteria which would eventually be developed out of analysis of the collected information. We felt that this would result in larger pools of applicants to the schools and in some cases raise the qualitative level of applicants who are accepted.

On a pilot basis, I believe that the American Association of Dental Schools might consider supporting this and I would like to see this proposal transmitted to the new standing committee on student affairs that will be responsible for admissions activity under the reorganization of the Association.

In discussing the benefits of the conference, the group felt that they had benefited considerably by the opportunity to exchange information with people working on similar problems, and they felt very strongly about having some mechanism for continuing contact. It was suggested that perhaps a central address or central office could be provided that would serve to collect and disseminate information of interest to people working in the computer area. It was also suggested that perhaps a survey be made twice a year on ongoing activities, indicating the individuals involved, with emphasis on what the program is and providing sufficient information so that an inquirer could contact the proper individual for full details. There was also some discussion of improving the usefulness of such a document by having people indicate honestly what problems they had experienced to help their colleagues avoid making the same mistakes.

I think I have covered the highlights of the admissions group meetings. There was considerable discussion of desirable next steps once we have achieved the goal of establishing compatible data bases in the schools and using them on a wide scale basis for admissions. One suggestion was to follow students after graduation in order to develop some better criteria than now exist for evaluating the effectiveness of dental education programs. Evaluation, as far as the dental schools are concerned, now ends with the individual taking the National Board Examination. With renewed interest in continuing education, and the possibility that relicensing will be in some way related to participation in continuing education, development of some evaluation criterion based on post-graduation performance will become more important in the future.

Project Abstract: UNIVERSITY OF ALABAMA Computer Assistance in Admissions at the School of Dentistry

PROJECT GOALS were related to the fact that the number of applications for admission to the School of Dentistry was increasing, while the adequacy of selection procedures was decreasing. A small fact-finding committee, set up to review alternative solutions, recommended complete investigation of computer use for development of

1. a more efficient admissions system, and
2. an information system that would provide data on students as applicants, scholars, clinicians and alumni.

IMPLEMENTATION was accomplished some three years later when Phase I of the project—the admissions system—became operable. Basically, the system involves coding and entering applicant information, subjecting this information to the program which performs a number of evaluative operations, and distributing this data in print-out form to the members of the Admissions Committee.

Phase II of the project is concerned with recording grades and class standing. Date collection began with freshmen students and is expanding by adding successive entering classes. After four years, all levels will have computerized records. Such data is made available each quarter to promotions committees and to students.

Recording and evaluating students' progress in clinical coursework constitute Phase III. Appropriate programs have been written and are undergoing tests. The system should be operational in the near future.

STAFF includes a secretary-coder in the admissions office and a programmer at the Computer Center. The staff of the Computer Center is available on a consulting basis.

SPECIAL PROBLEMS have been encountered in dealing with multi-departmental responsibilities of staff members, a situation that contributes to work slowdown. Programmers are in limited supply and many have left the school to accept better positions. Considerable effort has been expended in clarifying the objectives of the computer-assisted admissions system for the benefit of faculty members and administrators, i.e., assuring them that the system does not bypass the Admissions Committee, which in fact makes all final selection decisions. Exchange of electronically-processed information with other schools has been hampered by differences in coding, hardware, etc.

FUTURE PLANS call for the introduction of Phase IV which would provide information on alumni. Data collection would begin in several years with the first group of graduates whose records are entirely computerized. Records of earlier graduates whose records are entirely computerized. Records of earlier graduates would be worked into the system in stages. Exchange of data with other schools and with professional associations is also contemplated. Work is planned in the development of translations and conventions that would enhance compatibility between systems.

Clarence E. Klapper, Ph.D.
Chairman, Admissions Committee

Project Abstract: UNIVERSITY OF TEXAS Acquisition of an Electronic Data Processing System for the Dental Branch

PROJECT GOALS revolve around improved control of information regarding applicant selection and student progress, as well as more effective management of patient records. Production of summary reports on operations in the Dental Branch, handling of large numbers of patients and transactions, and formulation of an optimal response to changing clinical techniques have contributed to the need.

IMPLEMENTATION has been broken down into five phases. Phase I is concerned with applicant selection. Various reports and evaluations of applicants, including ranked lists, are electronically generated and presented to the Admissions Committee.

Phase II involves the handling of student records, including transcript evaluation, course grading and averaging, and preparation of final transcripts.

Phase III deals with management of clinical patient accounts and students' records regarding the patients. A standardized clinical grade card and a uniform number code for all clinical work have been devised.

Phase IV includes business operations and assisting the Business Office in systems preparation.

Phase V activity is related to curriculum construction. Along this line, code symbols corresponding to the logical sequences of a teaching topic have been developed and have proved to be useful in curriculum scheduling.

The COMPUTER (HARDWARE) SYSTEM is composed of the IBM Model 7094 located at the Common Research Computer Facility of the Texas Medical Center. An IBM Model 360/50 facility at Baylor Medical College is utilized by means of an IBM Model 2740 Remote Terminal using leased line connection. An IBM Model 2760 Optical Image Unit is on order.

PROGRAMMING LANGUAGES in use are FORTRAN IV for the IBM 7094 and PL/1 for the IBM 360/50. Programs originally written in COBOL have been translated to PL/1.

VOLUME of data processing is large in view of the fact that there are approximately 550 students at the Dental Branch and roughly 10,000 new patients making 75,000 visits annually.

The STAFF of the Data Processing Department includes a systems analyst-programmer, a senior keypunch operator-programmer and a secretary.

A SPECIAL PROBLEM lies in the lack of direct access to data in storage.

FUTURE PLANS provide for direct access entry to the systems, specifically by means of remote terminals for use in active input areas.

Donald C. Kroeger, Ph.D.
Chairman, Pharmacology

COMPUTER-ASSISTED INSTRUCTION

COMPUTER-ASSISTED INSTRUCTION

Report of Discussion Group

Richard S. MacKenzie, *Chairman*
Virginia G. Sturwold, *Recorder*

I would like to review our activities in two parts. First, I want to give you a quick idea about some of the informal presentations that were made concerning what is going on in computer-assisted instruction, and secondly, I want to touch on two problems that we discussed at length in our three meetings.

Presentations were made of CAI work at four different schools. The first was by John Weber of Cornell, who described an anatomy program which operates on the IBM 1500 system. The particular program covers several topics, but the one we discussed was teaching the function of the eye muscles. Cornell found that experts in anatomy could complete this program in about three minutes, whereas a novice might take two hours. They also tested the retention of the novices by giving them the program again after some time had elapsed and they found that the average time to go through the program a second time had dropped to about ten minutes, which indicated that some type of learning was clearly going on. One problem that was brought out in the discussion of this program was that it is extremely difficult for a single school to spend the amount of time necessary to develop a full-grown computer-assisted instruction program. Cornell has produced so far only about ten hours of instruction; presently they are questioning whether they should allocate the additional time and resources that will be necessary to develop a complete program. One solution Dr. Weber presented is approaching the medical schools at their annual meeting and asking for cooperation from the anatomy departments around the country. In this fashion one might gain the cooperation needed to produce a program of approximately 100 hours.

Another problem which we discussed was a plea that those of us who are involved in computer-assisted instruction should spend more time attending to the problem of behavioral or teaching objectives. That is, we should pay some attention to how these objectives, which are really intermediate objectives, fit in with achieving the total terminal objectives of the program. This amounts to questioning the validity of intermediate objectives in relation to the final products that we are trying to produce. The response to this was that the people who developed the objectives were experts in anatomy and the particular programs that have been developed have tied anatomic concepts to relevant clinical problems. This is one of the approaches at Cornell for linking intermediate and terminal objectives. I think the plea is one that deserves attention.

The second program we discussed was one that has been running at Stony Brook in New York. It was produced by Drs. Malcolm Skolnick and Mortimer Shakun and is one in which the computer scans radiographs and identifies diagnostic features of the radiograph. Topics of discussion were the problems of development, the program's potential in the diagnostic training of dental students, and its possible application not only to the reading of radiographs but also to such things as the screening of blood cells and the scanning of histological-pathological sections.

The third CAI program we discussed was done here in San Francisco at the University of California Medical Center and was demonstrated for us by Drs. Martin Kamp, Harvey Brody, and Richard Rozen. It has the general purpose of teaching sophomore dental students interview techniques useful in diagnostic problems, and employs the PILOT language developed by Dr. John Starkweather with emphasis on natural language processing capabilities.

The fourth program was the work of Dr. Devore Killip at Iowa. Their CAI demonstration project brought to light interesting problems, one of which was attitudes—the unwillingness of faculty to use computer-assisted instruction at all. The strategy used at Iowa was to get the faculty together and give them a two-hour course each week for a semester. This allowed the faculty to become well acquainted with computer-assisted instruction before making a decision regarding whether Iowa should go in this direction. After fifty-four faculty members had spent this time reviewing educational techniques and CAI, they decided that CAI was the direction they wanted to take. I think this is a very interesting approach. Unfortunately, it brings up the question of how they will be funded so that they can pursue the decision they made. This is obviously a question of general interest because CAI is so expensive.

Once we had finished with these informal presentations the group turned to discussing two problems. The first had to do with the amount of time and effort it takes to produce CAI materials, and with what can be done to help expedite the sharing of materials. For the short term, it was felt that this conference is itself serving the function of allowing us to know one another and become aware of ongoing programs so that we can communicate with one another. For the long run, we were interested in finding some way of sharing programs. Clearinghouses for information and depositories for finished programs were discussed. It was pointed out that Congress is presently holding open hearings on instructional technology with attention being paid to the problem of compatibility of machinery, computer languages, and so forth, and that these hearings may eventually result in sharing material among schools.

The second problem was the attitude of policy makers that is revealed in their frequently-asked question, "Isn't computer-assisted instruction just a glorified electronic device for turning pages?" Although some CAI work has been no better than a page-turning device, our group feels that its potential is much greater than that, particularly in view of the shortage of faculty members, the growing shortage of certain types of teaching patients, and the limitations on the types of learning experiences available for students. All these deficits can be overcome to some extent by a computer. For example, simulation of emergency situations by a computer is as possible as simulation of the routine patient by a manikin. Both uses will allow beginning students to learn things that will transfer very readily to the clinic. Simulation is one area, clearly, in which a computer can be used. Not to be overlooked is the potential of the computer for individualizing instruction because the computer has the capacity to adapt instruction to the student's background and ability. This is very important in health manpower training because it will reduce the training time required. The important point was made that the computer affords us an excellent way to study human learning in certain areas of instruction that we have not yet been able to touch with our conventional teaching. Although development costs are formidable, studies indicate that the costs of CAI in the long run are competitive with other types of instructional systems.

Finally, the point was made that by doing our experimenting now with computer-assisted instruction we will be able to guide the technology explosion in such a way that the hardware being developed will help in the teaching of dentistry in the future.

Project Abstract: CORNELL UNIVERSITY MEDICAL COLLEGE Research Directed Toward Increasing the Tutorial Capacities of the Computer in the Anatomical Sciences

PROJECT GOALS include:

1. Development of a pedagogical format for computer tutorial teaching in the basic medical sciences.
2. Increasing the technical competence of the computer as a tutor.
3. Simplification and improvement of the course preparation process.

While emphasis has been placed on increasing technical systems capabilities rather than on developing a mass of course material, some experimental programs have been written for the anatomical sciences.

IMPLEMENTATION in the first area consists of a branched conversational discussion program with no fixed beginning or end. A starting point is selected either by the student or by the computer. Correct answers to clinical problems associated with the discussions lead the student in a straight line from one discussion to the next. Responses and degree of comprehension are recognized and measured by means of key words and questions. Failure to answer a key question draws the student down into a branched discussion network.

Technical improvements in the second area involve:

1. A natural language approach based on key word analysis, along with prescanning in initial response recognition.
2. Artificial intelligence, i.e., incorporation into the program of the ability for modification of instruction based on "experience" with students.
3. Interactive graphics, providing the student with the ability to respond to detailed anatomical drawings on the face of a cathode ray tube (CRT) using a light pen to identify structures and to "draw" on the CRT face.

Finally, course authors are being assisted in preparing graphic materials for display by the development of a computer-controlled optical scanning system capable of coding a detailed picture in machine-readable form automatically. A further aid is provided by an author-interrogation program which takes the author step-by-step through the complicated decision-making process associated with writing a course program.

The COMPUTER (HARDWARE) SYSTEM consists of an IBM 1500/1130 system. PROGRAMMING LANGUAGES include COURSEWRITER II and 1130 assembler language.

STAFF assistance has been provided by two systems programmers and an illustrator. Student participation and contributions to the authoring and programming have been significant.

Support for the project is provided by Grant #50/68 from the National Fund for Medical Education.

John C. Weber, D.D.S. Assistant Professor, Anatomy	Wilbur D. Hagamen, M.D. Associate Professor, Anatomy

Project Abstract: OHIO STATE UNIVERSITY Computer-Assisted Instruction Experience at the College of Dentistry

PROJECT GOALS are:

1. To design and use computer-assisted instruction (CAI) as a supplement to classwork and for simulation of actual practice experiences.
2. To ascertain user attitudes toward CAI.
3. To evaluate the usefulness of CAI in meeting informational needs for continuing education of health professionals at the community level.

IMPLEMENTATION took the following forms. Two CAI programs were written, one for a course in Nutrition and the other a continuing-education course for dentists and physicians, entitled "Oral Cancer Recognition." The 10 to 14-hour Nutrition course is suitable as tutorial self-evaluation. The author, a faculty member of the Department of Biochemistry, College of Medicine, divided the course into eight topical areas: energy, carbohydrates, fats, etc.

The 4½ hour "Oral Cancer Recognition" course is the product of members of the dental faculty and is designed to evaluate CAI in terms of the needs of continuing professional education. The authors included six clinico-pathologic, conference-type cases in the course. Design strategy permitted user simulation of history-taking, physical observation and laboratory tests upon which to base diagnoses.

User attitudes toward CAI have been evaluated by means of an on-line computerized interview and by means of a standard questionnaire.

Of interest was the attempt by the CAI Study of the Ohio State Regional Medical Program (OSRMP) to train subject matter specialists as course authors. However, absorption of theories of programmed instruction and study of a programming language by such persons apparently hampered their writing efforts, possibly contributing to delay in program completion. A team approach to coursewriting is now recommended, utilizing the services of an author consultant (CAI language specialist), technical editor, input coder, and systems analyst.

The COMPUTER (HARDWARE) SYSTEM consists of a time-shared IBM 360/40 disk operating system linked by data telephone lines to two IBM 1050 typewriter terminals in the dental building (as well as to 10 community hsopitals in central Ohio). In addition, the College of Dentistry is now linked with the main campus Computer Center's IBM 360/50 through an IBM 2741 teletypewriter terminal.

PROGRAMMING LANGUAGES include CPS and COURSEWRITER III, Version 2 (IBM^R). A translation program between the two computer systems is now operational.

The system utilizes as a SPECIAL RECORDS FORMAT a random-access 35-millimeter projector and rear projection screen for visual presentations.

Because this project is a cooperative effort, STAFF includes personnel from the College of Dentistry, the College of Medicine and the OSRMP-CAI Study.

SPECIAL PROBLEMS were encountered in scheduling user time and in occasional system failures, due to excessive job demands on the time-shared hardware. Language translation between computer systems was another source of difficulty.

FUTURE PLANS are evolving around a major curriculum change in the College of Dentistry by 1971, coinciding with an enrollment increase of 50 freshmen. A faculty education program to acquaint instructors with CAI and a learning-laboratory based on CAI are contemplated. It is hoped that a program of simulated patient-management situations can be developed as well.

Gerald W. Gaston, D.D.S.
Project Director, The Ohio State
Regional Medical Program,
Computer-Assisted Instruction Study

Daniel E. Tira, Ph.D.
Education Specialist
College of Dentistry

Project Abstract: STATE UNIVERSITY OF NEW YORK AT STONY BROOK

Automated Scanning Analysis of Dental X-Rays Using the Clinical Decision Tree

PROJECT GOALS are:

1. Design and implementation of a hardware-software system capable of rapidly analyzing panoramic dental X-rays.
2. Implementation of diagnostic procedures using the obtained data to produce a clinical treatment plan and accompanying cost estimate, consistent with information on the Panorex X-ray.
3. Development of materials to facilitate instruction in X-ray reading, identification of significant radiographic data, diagnostic decision-making and treatment planning.

IMPLEMENTATION of the system involved development of a cathode ray tube flying spot scanner interfaced to an IBM 1130 computer through an analog-to-digital converter. This COMPUTER (HARDWARE) SYSTEM, operating under program control, incorporates an optical system which reads the optical density from a selected spot on the X-ray. This information is returned to the computer and subjected to the pattern analysis algorithm.

Analysis of the scanned X-ray is effected by a succession of binary logical choices incorporating an OVERALL scan to locate absence or presence of teeth, REGIONAL scans to determine relationships between teeth and to check properties of a whole quadrant, and LOCAL scans to determine properties of individual teeth.

The clinical decision tree is the combination of the set of "binary" questions about clinical properties of the mouth and the prescribed rules for proceeding to a new question based on previous answers. We will provide paradigms based on clinical requirements which examine individual data entries from the scanner on tooth or root location, tooth shape, density differences that indicate lesions or fillings, etc., and proceed on the basis of these findings to develop a profile for the particular patient. This profile is of course based on the particular path through the tree and is the sum of the individual decisions taken as a result of the working process.

PROGRAMMING LANGUAGES include IBM-provided software, in particular FORTRAN, in which a number of recognition operations and scanner controls have been written.

STAFF presently includes a mathematician, a communications scientist, a dentist specializing in radiography, a dentist-operations researcher, a data processing manager and an educational programmer.

SPECIAL PROBLEMS have been encountered in eliminating extraneous scanned data without affecting pertinent data and analysis capability, careful positioning of the head during the X-ray process, recognition of head and mouth positioning, control of development of the X-ray, and normalization of the film gray levels to achieve independence of the exposure and development process.

Most of these problems have been resolved by the use of a bite-block with embedded metal objects of known properties. Images of the metal objects on the resulting radiograph, which is a SPECIAL RECORD FORMAT, provide fiducial marks for the orientation and calibration of the radiographic image, and also provide a means of physically separating the images of the upper and lower teeth. A rapid statistical sampling procedure of the range of densities on a given film is performed at the beginning of the scanning process to supply information for the establishment of density thresholds for use in the analysis of the given film. The optical levels returned by the scanner may be normalized according to the observed opacity of the metal parts in the bite-block. This eliminates most of the difficulties inherent in variations of film exposure and development.

FUTURE PLANS call for teaching X-ray interpretation through the use of CAI materials. The clinical decision tree will be used in selection of appropriate course sequences. The goal of this portion of the effort is to facilitate a student's comparison of his analysis of an X-ray with the decision tree prescribed as part of the scanning process. Elucidation of the decision tree is thus seen as extremely useful. It may be used as a foundation to produce paradigms for general instruction. Coupled with the automated scanning process the decision tree may be used to derive an instructional review for an individual patient.

The project is supported by the U.S. Army Research and Development Command.

Malcolm H. Skolnick, Ph.D.
Director,
Biomedical Communications

Mortimer L. Shakun, D.D.S.
Clinical Investigator,
Dental X-ray Computer Project

Project Abstract: UNIVERSITY OF CALIFORNIA, SAN FRANCISCO MEDICAL CENTER
Computer-Simulated Patient for History-Taking at the School of Dentistry

The PROJECT GOAL is to develop a simulated patient interview, in which the computer acts as the "patient." The student, in "conversation" with the patient, must obtain a history and make a diagnosis. The simulated patient is designed to improve the generally poor translation of lecture-learned skills into clinical practice. A shortage of clinical patients and drawbacks of present teaching formats increase the need for an alternative method.

IMPLEMENTATION of the Chief Complaint, History of the Present Illness, and Medical History sections of the interview has been accomplished.

The interview itself is conversational in nature and can develop along a number of different lines depending upon the questions asked by the student. Formulation of the program includes the following operations:

1. Definition of the essential elements of the history.
2. Agreement on a minimum amount of information necessary to make a diagnosis.
3. Development of a design strategy corresponding to the decisions previously made regarding the history and diagnosis.
4. Storage, testing and modification of each program section as it is completed.
5. Student evaluation via an automated questionnaire and a modified checklist.

The COMPUTER (HARDWARE) SYSTEM is located at the Computer Center, San Francisco Medical Center. Actual hardware includes the IBM Model 360/50 with an IBM Model 2741 Remote Typewriter Terminal connected by means of telephone access.

Specialized PROGRAMMING LANGUAGES have been devised. The first one was COMPUTEST which allows unrestricted interactional sequences between student and computer. PILOT, or Programmed Instruction: Learning or Teaching, an outgrowth of COMPUTEST, is currently in use.

Television taping of student/"patient" interviews for evaluation is a SPECIAL RECORD FORMAT.

Project STAFF consists of several members of the dental faculty, personnel from the Instructional Division of the Office of Information Systems, U.C.M.C. and a staff member of the Dental Health Center, U.S.P.H.S.

FUTURE PLANS involve expansion of present operations with a view toward further improvement of student performance by freeing clinical faculty members to help students in specific problem areas. An interdisciplinary course in interviewing is also envisioned.

Harvey A. Brody, D.D.S.
Assistant Professor,
Oral Biology and Dentistry

Richard D. Rozen, D.D.S.
Specialist, Oral Biology

Martin Kamp, M.D.
Chief, Instructional Division
Office of Information Systems

Luigi F. Lucaccini, Ph.D.
Research Psychologist
Division of Dental Health, NIH

Project Abstract: UNIVERSITY OF IOWA
Exploratory Study of Computer-Assisted Instruction in Dentistry

The general PROJECT GOAL involves investigation of the potential of computer-assisted instruction (CAI) for presentation of dental subject matter content. The efforts of specialists in dentistry, education and computer science were combined in this case to achieve the following objectives:

1. To gain experience in the use of the IBM 1500 system.
2. To familiarize a selected number of the dental faculty with CAI.
3. To prepare a CAI demonstration program in a dental subject matter area.
4. To motivate the entire dental faculty toward course preparation for automated instruction.
5. To determine the feasibility of a major effort in CAI at Iowa.

IMPLEMENTATION of two main activities was undertaken concurrently. The orientation and training of dental faculty was accomplished through weekly seminars over a period of three months. Discussion topics included educational theory, programming techniques, computer technology, the IBM 1500 system and the COURSEWRITER II language.

At the same time, a demonstration course in Periodontics was being written for CAI. An expert consultant in Periodontics and a teaching member of the department were designated senior author and junior author respectively. The junior author was responsible for the teaching format (sequence) of the course while the senior author was responsible for its content. The demonstration course included a two-hour sample unit of instruction in addition to introductory sections. The attempt to accommodate various student readiness levels in terms of the branching capabilities of CAI proved to be quite a challenge for the authors.

Finally, participating faculty members tested the demonstration course during a field-trip to Science Research Associates (SRA) in Chicago, the location of the nearest working IBM 1500 system. Subjective reaction to the CAI experince was favorable. Thus far, no effort has been made to student-test the system.

The COMPUTER (HARDWARE) SYSTEM consisted of the IBM 1500 System available at SRA, Chicago. This particular unit was selected because it offered greater versatility than systems available on the Iowa campus.

The PROGRAMMING LANGUAGE was COURSEWRITER II. The program itself incorporated as many types of branch loops as could be devised at the time.

SPECIAL RECORD FORMATS included use of anatomical graphics and the Cathode Ray Tube (CRT) light pen for recognition of appropriate structures.

STAFF consisted of members of the dental, education and computer science faculties. This group designed and conducted the weekly seminar and consulted in the preparation of the demonstration course. Members of the group included the project director, the senior and junior authors, a programmer and an audiovisual technician.

SPECIAL PROBLEMS resulted from lack of experience with the 1500 system and took the form of language and hardware difficulties. Problems in course reduction for programming were encountered as well.

Devore E. Killip, D.D.S.
Director, Division of Education Resources

Project Abstract: UNIVERSITY OF PITTSBURGH
Computer-Assisted Instruction in Diagnosis at the School of Dental Medicine

PROJECT GOALS are to provide a comprehensive assortment of learning experiences in diagnosis together with diagnostic services for a certain pool of patients needed in the clinical program.

Too few patients have been assigned to dental students to allow them to achieve the desired competency in diagnostic skills. In addition, a change in clinical curriculum toward total patient care has caused even fewer patients—and therefore fewer diagnostic experiences—to be assigned to students. The new plan calls for patient experiences in the first year. However, the number of available diagnostic patients has not been commensurate with either first or second year needs. Clearly an alternative source of diagnostic experience and service is necessary.

IMPLEMENTATION of the project has not yet taken place. However, procedures have been developed and are ready for programming. The essential feature of the program will be complex analysis capability to enable students to probe deeply into a selected number of patient histories. Students will take a history, in standard-sheet form, and will do a simulated physical examination as part of the in-depth problem solving/problem posing process.

The COMPUTER (HARDWARE) SYSTEM includes an IBM 360/50 located at the University Computer Center, and two IBM 2741 terminals and one IBM 1052 terminal in the dental school.

A SPECIAL PROBLEM is the lack of financial support, which has thus far prevented implementation of the project.

FUTURE PLANS include program expansion to provide:

1. Experience in treatment planning.
2. Adjustment of various aspects of the operations in accordance with observed results.
3. Improvement of the mechanisms whereby learning pace can be regulated individually.
4. Contribution to and participation in an inter-university bank of programmed cases.

Roy T. Durocher, D.D.S.
Director of Clinics

Project Abstract: DENTAL HEALTH CENTER
Development of an Automated Dental Training Simulator

The PROJECT GOAL is to develop a full-form, computer-controlled dental training simulator. The manikin-like device would replace such items as "tooth simulators," etc., and would provide a closer correspondence between clinical and laboratory learning experiences in operative dentistry.

Actual IMPLEMENTATION of the project has not yet taken place. However, preliminary investigations are being conducted. The design of the desired simulator is expected to be very much like that of SIM ONE, a medical training manikin developed jointly by Sierra Engineering Company, Aerojet-General Corporation and the University of Southern California. The apparatus has been used to advantage in training anesthesiologists.

In dentistry, skills learned in certain pre-clinical laboratory situations bear little resemblance to those needed in clinical practice. In many instances, students must unlearn laboratory skills when they enter clinical training. Currently employed pre-clinical teaching devices often lack significant characteristics present in patients. For this reason, the full-form dental training simulator will be equipped with complete face, oral cavity, tongue, saliva, limited jaw movement and sensory mechanisms to register pain and heat.

Project STAFF is associated with the Professional Education Branch of the Division of Dental Health, BHME, NIH, San Francisco, California.

FUTURE PLANS involve using the results of feasibility and capability studies to design a workable model of the simulator. A second phase consisting of product testing, and redesign, if required, is contemplated in conjunction with the first phase. Incorporation of a computer for purposes of manikin control, as well as to record performance will constitute a third phase of operation. The possibility of operating several simulators from one general purpose computer will be considered.

Donald F. Carter
Design Engineer

Luigi F. Lucaccini, Ph.D.
Research Psychologist

Dale W. Podshadley, D.D.S.
Chief of Branch

Professional Education Branch
Division of Dental Health,
NIH, San Francisco

DENTAL SCHOOL OPERATIONS AND EDUCATIONAL ADMINISTRATION

DENTAL SCHOOL OPERATIONS AND EDUCATIONAL ADMINISTRATION

Report of Discussion Group

Clifton E. Crandell, *Chairman*
James M. Barnett, *Recorder*

I have organized our discussions into three sections—first, a review of current usage of computers in dental school administration; second, a discussion of hardware, software, and administrative problems; and third, identification of some areas that we feel need to be explored in the future.

The current activities we talked about are so numerous that I can only list them. We discussed billing, test scoring, averaging of grades, computing class standings, use of factor analysis, test item pools and item analysis, scheduling of students, scheduling of space, matching and assigning patients to students, maintaining patients' records, preparing form letters, problems of recording clinical achievement, grading faculty performance, allocation of resources, maintaining supply inventory, purchasing, patient followup and recall, grading for counseling purposes, handling student admissions, and information retrieval. It was observed that the number of dental schools employing computerized recordkeeping operations is large and growing. It was felt that most of these operations are executed satisfactorily although manual or non-computer methods are still widely used.

In discussing hardware, it appeared that in general it is probably better to rent than to own. On the other hand, a thorough systems analysis must be done first, including a clear and precise specification of output, before an appropriate decision can be made about hardware. It was suggested that tabulating equipment might be more desirable than computer equipment for many of the administrative functions we discussed. An extension of this system selection problem includes consideration of time-sharing systems versus batch processing, and stand-alone versus remote terminal systems. Input forms that were mentioned as being currently in use included mark sense cards, optically scanned forms, Hollerith cards, port-a-punch, and manual methods. One administrative problem discussed was shifting from grades to other motivational mechanisms such as a flexible curriculum with acceleration features that would permit a student to graduate in three years or less. Another problem was ways and means of getting cooperation from faculty and students in implementing an automated system. The problem was recognized as important, but solutions were not clear.

In proposing directions for the future, two general areas were touched upon—the activities that are needed, and the personnel necessary to carry them out. It was agreed that a systems approach to the problem of dental school operations is desirable. Even if a systems analyst does not generate a better solution, the administrator will have the benefit of a critical review on which to base his decision.

Payment systems were considered from several aspects—prepayment schemes, postpayment, third party collections, and billing procedures all received attention. The possiblity of basing clinical fees on time or difficulty rather than on piece-work fees was also discussed. It was observed that requiring the student to collect the fee was demeaning and of no educational value.

A management information system is needed in each dental school to provide data on the cost of operation, cost of services, and utilization of facilities. Such a system would provide valuable input into decisions about contracts for services under insurance or prepaid treatment plans. Considerable discussion was generated about the qualifications and administrative relationship of the person or group of persons who directs the data processing effort. Should the position be filled by a dentist with special training, or by an information specialist with dental training, or should it be managed on a cooperative basis by members of each discipline? We did not reach a decision on this point; in practice, available funds and personnel will probably influence this decision in the individual insitution. The group agreed that the director should report directly to the highest level of administration.

The establishment of a formal system for future exchange of information such as a newsletter or additional conferences is certainly needed. The outlook for the exchange of programs will be more favorable when they are machine-independent. The sharing of resources in the future appears to be essential because of the high costs involved in program preparation.

Project Abstract: HARVARD UNIVERSITY
Computer-Assisted Record Systems for Clinical Projects at the School of Dental Medicine

The PROJECT GOAL is the development of automated systems for data acquisition, processing and analysis of epidemiological and clinical projects.

In regard to IMPLEMENTATION, a decision was made to avoid the time-consuming, often inaccurate manual translation of data from source materials to punched cards by utilizing original documents of data entry which could be machine-processed. Optically scanned forms incorporating pre-coded marking positions which provide for numerous response possiblities were considered the most appropriate for data collection and management.

Three projects have been undertaken so far. The first (Automated Record System for Computer Programming of Dental Treatment) encompassed the development of an oral examination record, which could be processed directly by an optical scanning machine, and a related computer program that generates treatment plans. The system is a compromise between sufficient and all-inclusive detail. Consequently, its use has been limited to general rather than special practice situations and has excluded emergency procedures and unusual surgery. The system is designed to cover 95 rather than 100% of cases.

Over 500 computer-generated treatment plans have been compared with plans developed independently for the same patients by dentists. Agreement between treatment plans generated by computer and by dentists was 95%. Discrepancies observed were either the result of an inadequate data base or deviations by the dentists from criteria previously agreed upon.

The second project (Automated Oral Examination Record for Epidemiological Studies) involved the development of a computer-aided system for the summarization and statistical analysis of results of dental examinations. The system has been designed for use in studies of dental caries prevalence and clinical trials. Computer programs have been prepared to edit data, provide summary information, make surface comparisons after successive examinations and perform statistical analyses.

The third project (Computer Assisted System for Nutritional Analysis in Epidemiological Studies) was designed to develop a computer-aided system for the summarization of findings of interviews concerning nutritional intakes. Utilization of food value tables, calculation of individual nutrients and other operations are done by computer. The system is useful in dietary research projects and in preventive dentistry.

The COMPUTER (HARDWARE) SYSTEM consisted of the IBM 360/50. FORTRAN IV was the PROGRAMMING LANGUAGE used. In this project, pre-coded optically scannned sheets served as SPECIAL RECORD FORMATS.

The STAFF for these projects consisted of the principal investigator plus consultants. Establishment of a separate computing center was avoided. Costs and personnel problems were minimized by renting use of hardware and purchasing services.

FUTURE PLANS call for development of new methods to meet demands of increased data acquisition, as well as for greater use of the systems by students.

Robert L. Glass, D.M.D., Dr. P.H.
Associate Professor, Dentistry

Project Abstract: MEDICAL COLLEGE OF GEORGIA
Computer Use at the School of Dentistry

The PROJECT GOAL is to inaugurate a program of computer use unique to the School of Dentistry. At present, computer use by the School of Dentistry is limited to programs of general application to the institution: budget control, warehouse inventory control and a file on applicant information and admissions decisions. Faculty members have made use of the facilities on an individual basis.

Projects for potential IMPLEMENTATION include a system incorporating records for clinical instructors, students, and patients; a system of preventive maintenance, associated with the class scheduling system; a system of inventory control, monitoring obsolescence and reordering of materials; and, perhaps most exciting, a system capable of simulating the effects of policy changes.

The COMPUTER (HARDWARE) SYSTEM consists of the IBM 360/30, located at the Medical College of Georgia Computer Center.

The STAFF of the Computer Center includes a director, assistant director, manager of quality control, supervisor of programmers, systems analysts, programmers, operators and clerical personnel.

P. Kenneth Morse, Ph.D.
Educational Psychologist

Project Abstract: NEW JERSEY COLLEGE OF MEDICINE AND DENTISTRY

Computer Applications Planned

The PROJECT GOAL is development of an operational computer system for use in connection with the new dental school now under construction. At present, the College of Dentistry does not have such a computer network, although investigation of candidate systems is underway.

It is hoped that the programs developed will have application in the following areas:

1. Matching complexity of patients' dental treatment with students' technical and academic capabilities.
2. Monitoring of consistency and continuity of treatment in relation to established treatment plan.
3. Storage and print-out of students' performance (grading).
4. Student attendance in terms of appointments in each clinical discipline.
5. Billing statements for completed dental treatment.
6. Admissions procedures programmed to assist in the screening of applicants.
7. Programmed instruction in clinical and basic science courses with an emphasis on correlating the two.
8. Research data analysis to establish statistical significance of results.

Ian C. Bennett, D.D.S.
Dean

LeRoy A. Parker, Jr., D.D.S.
Assistant Dean, Clinical Affairs

Project Abstract: TUFTS UNIVERSITY
SCASER: Student Clinic Assignment Schedule Evaluation and Report Program at the School of Dental Medicine

SCASER is a computer program designed to aid in the preparation and evaluation of yearly student assignment schedules for a dental school and, once these are determined, to prepare suitable output reports to convey this scheduling information to the appropriate areas. The program generates any or all of six output reports on request.

Output Report No. 1 is an Individual Student Assignment Schedule showing daily assignments, morning and afternoon, in the time period scheduled. In present form, up to forty weeks can be displayed on one page of computer output.

Report No. 2, the Weekly Student Locator, is a guide for locating a student during a school day and indicates the assignments for all students in a given class on a weekly basis.

Reports No. 3 and No. 4 list the students who are assigned to a given department every morning and afternoon for every week in the scheduling period. Student identification numbers (if any) are used in No. 3 and actual names in No. 4.

Report No. 5 is a Class Size Print-out, prepared for each day of the time period being scheduled, that indicates the utilization of facilities, i.e., the number of students assigned to each teaching area on a morning/afternoon basis.

Report No. 6 lists the number of times each student is assigned to a given teaching area in a given scheduling period, and is used to make certain that the scheduling procedure assigns students the requisite number of times to each teaching area.

SCASER has been found useful not only in handling actual scheduling tasks but also as a tool for analyzing the effects of proposed alternative schedule changes.

The PROGRAMMING LANGUAGE is FORTRAN II, except for two short subroutines written in assembly language. The COMPUTER (HARDWARE) SYSTEM currently includes the IBM 7094 and the Control Data Corporation 6600.

With respect to data processing VOLUME, a schedule for 150 students for 40 weeks requires 150 x 40 x 10, or 60,000 individual student assignments. Approximately 2–3 man-days are required to prepare the input information in machine-readable form for a scheduling run of this size. The scheduling run itself requires about 40 minutes on the 7094, and 18 minutes on the 6600.

This work was supported in part by funds from a Public Health Service Special Research Fellowship from the Division of Dental Health, NIH.

Mortimer L. Shakun, D.D.S.
Research Associate

Project Abstract: UNIVERSITY OF CALIFORNIA AT LOS ANGELES
Computer Program in Clinical Management at the School of Dentistry

The PROJECT GOAL is to establish a scientific information system for intelligent decision making, patient assignment and data retrieval. The latter is to include patient histories and student clinical achievements stored for purposes of evaluation and research. A further objective is to make as few demands as possible on students and staff while developing this system.

IMPLEMENTATION has taken the form of a dental records computer system composed of six programs: edit, update, student status report, patient queue report, division report and patient status report.

The edit program verifies cards and prepares them for the update program, which services a master file and generates work files for the four work programs.

The student status report program, produced weekly, is divided into four parts:

1. Treatment information regarding assigned patients.
2. List of treatments completed, whether assigned or not.
3. Summary of clinical work in terms of requirements for graduation.
4. Clinical performance record.

The patient queue program processes the treatment plan record for unassigned patients and is used in connection with part three of the student status report. The division report program generates information on all student accomplishments within a division, including ranked lists of student performance on particular operations. Finally, the patient status report program prints out stored and updated data in response to requests for information on certain patients.

The COMPUTER (HARDWARE) SYSTEM includes the IBM 360/50 and IBM 360/91, plus peripheral devices located at the Hospital Data Processing Facility and the Health Sciences Computing Facility.

PROGRAMMING LANGUAGES in use are COBOL, 360 assembly language (BAL), PL/1, and FORTRAN.

The STAFF of the Dental Data Processing Division includes a programmer, a programmer trainee, a keypunch operator, and a verifier, in addition to two clerks in patient assignment and a secretary.

FUTURE PLANS involve development of

1. a special payment program to streamline financial mangement,
2. a retrieval program for evaluation and research, and
3. computer-assisted instruction (CAI) materials.

Samuel Cheng, D.D.S.
Assistant Clinic Director

Project Abstract: UNIVERSITY OF IOWA Flexible Scheduling System at the College of Dentistry

PROJECT GOALS revolve around the development of a model of a flexible dental education program, i.e., a departure from the traditional lockstep scheduling of the professional curriculum.

Partial IMPLEMENTATION has occurred in the form of the development and adoption of a new curriculum by the faculty of the College of Dentistry. The curriculum focuses effort on a core of knowledge, skills, and abilities which are common to all dental specialties and activities.

A student will not be compelled to learn what only a small percentage may ever have reason to apply. Interest in special areas may be pursued by means of elective courses and students will be encouraged to be innovative in what courses they take and the sequence in which they take them. An enrichment program has been developed to assist them in this regard. In a further change, comprehensive clinical experience—diagnosis, treatment planning, and actual treatment done by the same student—has been made part of the curriculum.

In such a potentially random, individualized curriculum, continuity, both horizontal and vertical, will be difficult to maintain. In addition, the comprehensive patient care system will require coordination of diagnosis, selection, and scheduling of patients with individualized scheduling of students and clinical staff.

Development of a system which would

1. permit "shuffling" of numerous educational variables and curricular options,
2. meet the needs of the students,
3. make an effective use of instructional staff, and
4. maximize use of facilities,

can be accomplished by means of computer procedures. The proposed project will involve combined resources of the College of Dentistry, the Measurement Research Center, and University Computer Center. The following major steps are planned:

1. Systems analysis of departmental scheduling needs.
2. Simulation of flexible schedule.
3. Analysis of clinical operations.
4. Development of computer programs (master schedule).
5. Design of supporting subsystems.

The primary outcome of the proposed project will be a working system of flexible and pedagogically sound scheduling of facilities, faculty, students, patients, subject matter, and course content.

STAFF includes a project director, a project associate director, a systems analyst, a programmer, clerical personnel and consultants.

Richard M. Jacobs, D.D.S., Ph.D.
Associate Dean

Project Abstract: UNIVERSITY OF KENTUCKY
Computer Usage in a Dental Clinical Teaching Program at the College of Dentistry

The PROJECT GOAL is to provide current and comprehensive information regarding the work of students in the Clinical Teaching Program, as well as on treatment plans and patient progress. The clinic curriculum is based on the total patient care approach.

IMPLEMENTATION of the first phase has been accomplished by means of data acquisition procedures and appropriate computer programs designed to generate summaries of clinical work done by students. Data regarding a designated number of distinct clinical procedures are recorded on preprinted data cards during the clinical period and subsequently processed.

The results of screening examinations of patients are processed to assist the Coordinator of Patient Care in assigning a balanced variety of patients to a student. A program has been developed which periodically generates a Patient Assignment Report indicating patient assignments and date of first appointment. Once a patient has been seen and a diagnosis made, information regarding him is deleted from the Patient Assignment Report and added to the Treatment Plan Report, which lists treatment plan, supervising department, and dates of completed procedures.

Finally, in addition to these larger and more integrated systems, a number of separate programs have been written for analysis of the charges sent to the Business Office, and of the cash receipts, for control of student equipment, and for patient recall purposes.

The COMPUTER (HARDWARE) SYSTEM is located in the Computing Center and includes the IBM System 360/50 with 2314 disk unit. The PROGRAMMING LANGUAGE employed is FORTRAN IV. The 360 Utility Sort and Merge has been used extensively.

VOLUME of data processing amounted to 50 hours of computer time in the last year of operation. This figure includes time spent on program development and debugging; keypunched input to the various programs totaled 45,000 cards.

The STAFF consists of an applications programmer/data coordinator (half-time), applications programmer/analyst (part-time) and a keypunch/key verifier operator (full-time).

FUTURE PLANS call for development of more and varied programs and for the provision of on-line disk storage and the installation of remote terminals to reduce the number of reports that must be generated periodically.

Richard C. Bartlett, D.M.D.	Garth L. Olde, Ph.D.
Coordinator, Patient Care	Director, Medical Center Computer Services

Project Abstract: UNIVERSITY OF MARYLAND Computer Usage for Undergraduate Dental Teaching Programs

PROJECT GOALS involve more efficient handling of data related to scheduling, grades, clinical performance, counseling, student and patient progress, professional academic performance, and evaluation and research, as well as development of direct access inputs for information retrieval and design of computer-assisted instruction (CAI) programs.

IMPLEMENTATION of the first group of activities has been accomplished to a large extent, especially in the areas of class scheduling, student scheduling, student performance, and patient assignment. Most of the programs are relatively simple ones designed to store and satisfactorily retrieve large amounts of data recorded on a daily basis. Research applications of the computer are currently being investigated.

The COMPUTER (HARDWARE) SYSTEM is the IBM 360/44 located at the Health Sciences Computer Center. FORTRAN is employed as the PROGRAMMING LANGUAGE.

FUTURE PLANS involve work on the second group of goals, including installation of remote terminals and development of CAI materials.

Charles E. Barr, D.D.S.
Assistant Dean for Clinical Sciences

Project Abstract: UNIVERSITY OF NEBRASKA Planned Computer Usage at the College of Dentistry

The PROJECT GOAL involves the development of needed computer-based systems. The College of Dentistry is not using a computer facility at present.

IMPLEMENTATION of goals is expected to take the form of an information storage and retrieval system with the following capabilities:

1. Comparison of patient progress with previously diagnosed patient needs.
2. Comparison of performance of students working under the case system (comprehensive oral health care) with that of students working under a "requirements" system.
3. Matching of patient needs with student needs.
4. Providing dental manpower and demographic information on the State of Nebraska.
5. Processing research data.

The University has a COMPUTER (HARDWARE) SYSTEM that includes an IBM 360/65. FORTRAN IV and COBOL are in use as PROGRAMMING LANGUAGES.

Gordon C. Vidmar, D.D.S.
Chairman, Preventive Dentistry and Community Health

Project Abstract: UNIVERSITY OF NORTH CAROLINA Operations Research in Clinical Dental Education at the School of Dentistry

PROJECT GOALS are:

1. To demonstrate the merits of linear programming techniques for the optimum allocation, scheduling and utilization of teaching staff and physical facilities in clinical dental education.

2. To demonstrate its practical application through the total patient care concept.

3. To make data available to other schools.

IMPLEMENTATION of the first phase began with an analysis of the clinical teaching situation and subsequent identification of significant factors regarding the effectiveness and efficiency of clinical instruction.

These factors were then simulated conceptually in a mathematical model under the assumption that a linear relationship exists among them. The model was fed into the computer and studied using linear programming techniques. Results constituted an identification of the elements that represent the clinical situation. Low-cost, nondisruptive experiments in curriculum change can be conducted using this working model.

The second phase involved a practical application of the linear programming model in the implementation of a total patient care project. The project was designed to provide an additional data base for the model; acquaint students, faculty and staff with automatic data processing; and introduce a new curriculum based on the comprehensive care concept.

Participant selection was accomplished by dividing the junior class into five academic levels and choosing one student at random from each level. Students were assigned patients whose cases would provide a balanced clinical experience equal to or greater than the usual clinical requirements in the various departments. A program designed to match students and patients is not yet operational.

The students' progress has been monitored and recorded for eventual comparison with the performance of the rest of the class which served as the control group. Several criteria of project evaluation include, on a tentative basis, the quality, quantity and speed of clinical procedures and scores on mock board examinations, assessed using computer-executed statistical techniques.

Clifton E. Crandell, D.D.S.
Associate Professor, Oral Diagnosis

STUDENT EVALUATION IN CLINICAL COURSE WORK

STUDENT EVALUATION IN CLINICAL COURSE WORK

Report of Discussion Group

Paul Ehrlich, *Chairman*
Dean W. Darby, *Recorder*

In our sessions we first went around the table and asked each group member to tell us a little bit about the work going on in his school and what he would like to see implemented in the future. I would like to present this material to you in an outline form in the interest of time.

First, we discussed systems in operation or near completion. We found it was impossible to stay purely in student evaluation because it is tied so closely to other aspects of administration. Under systems in operation, our first topic was matching student needs and abilities with patient needs—as tied to the total patient care concept. Several schools have clinical records systems in operation or underway. In the area of student rating, one of the schools also has an examiner rating system using a method of adjusting grades according to the student's previous grading history. Many pros and cons developed on that subject. We then moved into student and patient billing systems. From the administrative point of view, both of these must be taken into consideration because we are all involved, or soon will be, in third-party payments. Also mentioned were the recall systems that some schools have for periodontics, pedodontics, and preventive dentistry; backup card systems in grading in case there are downtime problems on the computer; and systems for inventory control, class scheduling, patient screening, and delinquency reporting.

As for systems planned or being developed, we mentioned complete patient information systems, matching student needs and ability with patient needs; computer-assisted instruction; and student pre-dental performance records for admission which might include, it was suggested, psychological testing aspects which most of us neglect. Also under development are billing systems, several methods of student ratings, special assignment criteria, oral diagnostic systems, methods for treatment planning, inventory control and clinical utilization of reports.

The second major area of discussion was common problems and needs. These included money, personnel problems, cooperation (people problems), and coordination among students, faculty, and computer centers. There was a consensus that the faculty provided most of the obstacles to getting the job done. The existence of decentralized facilities is also a problem in many schools. Most frequently mentioned was the need to share selected programs and systems and to reduce duplication. Solutions could take the form of a system for interchange of information or a series of core or profile packages that could be adapted to local needs, e.g., profile packages for student rating, or for matching patient needs with student needs and ability.

A crucial problem is ensuring the acceptance and utility of the final product. Specialists familiar with dental problems design reports that are more meaningful, usable, and readable, than those who are purely computer specialists. Those of us who have been in operation for some time realize that unless the material you submit to the faculty and staff is in a usable form or is needed, it is of little value. A means for feedback to those who provide the inputs is very important in order to get their cooperation. This includes the faculty *and* the students. Many of the faculty involved had never seen one of the print-outs that were obtained from the input they provided. In many cases, it appeared that it is the little things that make a system successful—for instance, card size, ease of handling for an instructor, the attitude toward the system, and a personalized print-out.

Now, among the things that the participants hoped to get from the conference, the two most frequently mentioned were knowledge of ongoing programs and help in the design and planning of programs and systems. Two significant proposals were made. The first was to form a committee of representatives of schools who currently use clinical evaluation and related programs. This committee will attempt to form a foundation for a general clinical evaluation program which will have application to all schools. Second, I would like to invite all participants at this conference to become part of the information-exchange group that was formed at the North Carolina Conference on Comprehensive Care in Clinical Dental Education. All participants will be contacted shortly by questionnaire.

Project Abstract: CASE WESTERN RESERVE UNIVERSITY Computer-Assisted Clinical Grading at the School of Dentistry

The PROJECT GOAL is to locate and correct shortcomings in the operative dentistry teaching program and to give students remedial help in problem areas. The program varies somewhat in different departments.

A preprinted and pre-coded grade card is made out for each step of each operation. Students are graded in terms of criteria of technical competence, professional behavior and reasoning ability peculiar to each operation. All grade cards are collected daily and a computer card is punched for each one. Finally, the cards are read into the computer and the program generates a magnetic tape sorted by various characteristics, e.g., patient number, student's class, clinical procedure, etc.

A print-out displays the data, including an average grade for each category of the procedure. This type of measure provides a better indication of areas of weakness than an average grade over all categories.

The system has in fact expanded the grading base because student grades are based on a broader group of criteria. In addition, grading has become more accurate and instances of "blanket grading" have been exposed.

The General Electric 225 computer comprises the COMPUTER (HARDWARE) SYSTEM. The PROGRAMMING LANGUAGE is VFAP, an assembly language for GE 200-series computers.

The borrowed STAFF is composed of a keypuncher and two consultants.

FUTURE PLANS involve employing a keypunch operator responsible only to the School of Dentistry.

John P. H. Clark, D.D.S.
Professor, Pharmacology and Operative Dentistry

Project Abstract: EMORY UNIVERSITY
Data Processing Systems at the School of Dentistry

PROJECT GOALS are to aid the Director of the Diagnostic Clinic in maintaining control of patient acceptance and assignment, and to provide administration and faculty with a comprehensive record of clinical treatment rendered, allowing them to evaluate both quantitatively and qualitatively.

IMPLEMENTATION involves two computer related programs now in use. The first is a student scheduling program which generates a master schedule for one academic year showing Junior and Senior assignments to the various departments in which block assignment of students is applicable, including Oral Medicine (Diagnosis and Radiology), Emergency Service, Dental Assistant Utilization, Oral Surgery, Hospital Training and Pedodontics.

The. second program handles patient admittance; assignment; treatment progress, as well as student clinical accomplishment; patient load (treatment plans); and evaluation.

The COMPUTER (HARDWARE) SYSTEM consists of the RCA Spectra 70/55 located at the Computer Center. COBOL is the PROGRAMMING LANGUAGE in use.

A SPECIAL RECORD FORMAT, the Standard Register Company Source Records System, was selected for use on the project. The system employs "zip-card" sets and master plates, resembling credit cards, containing static data. "Zip-cards," like computer cards, are punched but the former have fewer data spaces and reduce error. Supporting programs in accounting, grading, patient recall and other areas have been developed using this records management system.

STAFF includes two programmers from the University Computer Center and two consultants from the Standard Register Company.

FUTURE PLANS call for achieving maximum machine utilization for matching the needs of clinic patients with those of students.

Charles L. Halstead, D.D.S.
Chairman, Oral Medicine

Project Abstract: LOMA LINDA UNIVERSITY
Evaluation of Student Clinical Achievement by Computer at the School of Dentistry

The PROJECT GOAL is to record and evaluate student progress in periodontal work with the aid of a computer.

Insofar as IMPLEMENTATION is concerned, a separate port-a-punch card is made up for each procedure. It is the student's responsibility to punch the appropriate information, which includes student number, patient number and procedure completed, on each card and have it initialed by the instructor, who punches out his number and the appropriate grade. The student must avoid committing any of the numerous errors possible in card punching.

A code of abbreviations suitable for entry on cards has been developed for various procedures in periodontic practice, such as initial preparation, case reevaluation, completion of active therapy and recall-maintenance procedures. A credit system corresponding to these procedures has also been devised. Extra credit may be given in especially difficult cases and/or individual procedures.

Students receive two types of clinical progress report print-outs: a cumulative report of all work completed to date and a periodic report containing all work completed since the last print-out.

Again, it is the student's responsibility to see that these reports are accurate and complete. Errors or omissions may be rectified by submitting a computer card containing the exact information to be deleted or added to the clinical instructor involved with the original problem.

FUTURE PLANS include computer assignment of patients, and computer-managed instruction in the following courses: Oral Diagnosis, Dental Materials, Cancer Recognition and Diagnosis, Practice Management, and Periodontology.

Edwin M. Collins, D.D.S.
Assistant Dean

G. Conrad Hornbuckle, D.D.S.
Assistant Professor, Oral Medicine

Project Abstract: MEDICAL UNIVERSITY OF SOUTH CAROLINA

Computerized Records Program at the School of Dentistry

The PROJECT GOAL is a modern, efficient records program at the School of Dentistry.

To date, IMPLEMENTATION has been achieved in activities associated with student clinical grading and accomplishments, clinical fees collected, and patient registration information.

The COMPUTER (HARDWARE) SYSTEM is composed of the IBM System 360/30 and peripheral equipment, located in the Data Processing Center. The Center has, in addition, an IBM 2780 Data Transmission Terminal connected with the Common Research Computer Facility at Houston, Texas.

FUTURE PLANS call for the following:

1. A system for matching patient and student clinical requirements for assignment purposes.
2. Recording of laboratory activities and associated grading.
3. Recording of didactic activities and associated grading.
4. Establishment of a clinical and microscopic pathology registry.

Benjamin F. Lawson, D.D.S.
Chairman, Oral Medicine/Periodontology

Project Abstract: STATE UNIVERSITY OF NEW YORK AT BUFFALO

The Application of Computer Science to the Administration of the School of Dentistry

PROJECT GOALS include integration of the health care problems of the patient with student clinical training requirements. This involves development of more administratively efficient systems for retrieval of patient records and scientific data and for generation of student progress reports. The clinical training program is considered the center of the entire educational effort.

In the initial stage of IMPLEMENTATION, the School of Dentistry has begun to accumulate an "information reservoir," specific entry to which is made through specialized computer programs.

A master file of student and patient information is being developed to contain such data as

1. static information on patients (address, phone, etc.),
2. treatment plan information, including priorities and degree of difficulty,
3. patient assignment information, based on availability, treatment requirements, urgency, etc.,
4. patient progress information to be compiled daily,
5. student progress reports which concisely display progress in each department and point out deficiencies,
6. billing information, and
7. limited scheduling information.

The COMPUTER (HARDWARE) SYSTEM is the CDC 6400. PROGRAMMING LANGUAGES include FORTRAN IV and COBOL.

Data processing VOLUMES are as follows: 500 to 700 cards keypunched per day; three to four card-to-tape runs per week; and three weekly and five monthly reports.

STAFF consists of a programmer/analyst, part-time programmer/analyst, keypunch operator and private consultants when available.

SPECIAL PROBLEMS include improper initial preparation and technical transcription of resource documents, limiting the accuracy of the results. Data reporting has been irregular because of incomplete development of the master file sections. Lack of control of patient information has been attributed to programming language problems.

It has been found that the nature of the data processing task is not completely compatible with available hardware. That is, the CDC 6400 is mathematically oriented, while the Dental School's needs revolve around summarizing, comparing and reformatting their data. The computing center has been of limited help, mainly because dental school problems are outside its main stream of activity.

FUTURE PLANS call for eliminating the need for "hard copy" processing by turning to hardware with display capability. In fact, an entirely different hardware system is presently under consideration.

Nelson L. Blackmore, D.D.S.
Chairman, Patient Admissions and Records

Project Abstract: TEMPLE UNIVERSITY
Computer-Assisted Student/Patient Management Procedures at the School of Dentistry

The PROJECT GOAL is to provide information regarding students' clinical progress, grades and grade averages to faculty and students in an automated, efficient manner.

IMPLEMENTATION initially involved selection of criteria by each department. Student performance during clinical experience is compared with those criteria and recorded on preprinted computer input cards. The cards are then fed into a National Cash Register machine which transfers the data to magnetic tape.

Tapes are sent to the National Cash Register Company's main office in Baltimore for print-out when needed. For all practical purposes, the system is fully debugged.

The National Cash Register Computer, located in Baltimore, and the NCR card read-in mechanism make up the COMPUTER (HARDWARE) SYSTEM.

VOLUME of data processing has been estimated at approximately 175 input cards daily. Transfer of data requires between sixty and ninety minutes for one operator—18% of the total man-hours used previously in keeping student grade and status records.

FUTURE PLANS are as follows:

1. To maintain an accurate administrative control over 8,000 patient records.
2. To maintain current knowledge as to the progress of each patient through the treatment plan.
3. To provide an effective recall system.
4. To allow storage and retrieval of information concerning the incidence of oral diseases.

Kendrick Brookreson, D.D.S. Chairman, Oral Diagnosis	William E. Crolius, D.D.S. Assistant Dean, Clinical Affairs

Project Abstract: UNIVERSITY OF MISSOURI–KANSAS CITY
A Computer-Supported Dental Educational System

PROJECT GOALS revolve around including information science and computer techniques in a revised dental curriculum and incorporating such instruction into an extensive program of computer applications in dental education.

IMPLEMENTATION of these objectives has been called the "Computer Supported Dental Education System," which encompasses:

1. Instruction in information science and computer techniques.
2. Computer-aided instruction.
3. Computer applications in educational research.
4. Traditional administrative applications in the mangement of clinical records including both performance of students and patient records.

First year students will be required to either demonstrate competence or take the course offered in computer science. Practical experience will be gained in the use of the dental information system as associated with clinical activities. Advanced courses in computer science will be offered as well.

At present, two major files are being compiled: a patient file, based on data from the oral diagnosis clinic, and a related student file, prepared by the clinical teachers. The patient file includes such information as assignment, treatment and recall, while the student file contains such data as clinical procedures, quality of performance and professional evaluation. Students are rated in terms of weightings, or measures of difficulty, given by the faculty to all clinical procedures.

Summary reports prepared from the student performance file are generated monthly and at the end of each semester. A mean quality index and an experience index are computed for each student. A list of students, ranked on each measure, is generated as well.

Project STAFF includes a director, a biostatistician, two programmers, a technical information scientist, an information clerk, four keypunch operators and two computer operators.

The previous card system was a SPECIAL PROBLEM in that it was cumbersome and it managed only a limited amount of information.

FUTURE PLANS involve:

1. Further development of computer-aided instruction, particularly through the acquisition and use of cathode ray tube terminals.
2. A redesign of the present records management system.
3. Utilization of the statistical advantages of a large enrollment for the purpose of educational research.

In addition, a new hardware system, featuring high-speed, direct-access storage, is being selected.

Homer C. Jamison, D.D.S., Dr. P.H.
Professor, Preventive and Community Dentistry

Project Abstract: UNIVERSITY OF PENNSYLVANIA Computer Applications at the School of Dental Medicine

PROJECT GOALS involve computerization of student evaluation, preclinical and clinical, and of educational administration in order to implement a program of Comprehensive Care.

IMPLEMENTATION will involve programs designed to handle student billing, grade reporting, patient monitoring, student monitoring and clinical scheduling.

The COMPUTER (HARDWARE) SYSTEM will consist of an IBM 360/40, with an IBM 360/75 as a backup unit. The PROGRAMMING LANGUAGE will be U.S.A. Standard COBOL, with possible subroutines in PL/1.

The Project STAFF is presently composed in large part of personnel from a private corporation contracted to assist in programming.

FUTURE PLANS call for a fully operational status by September 1970.

Anthony A. Vito, D.D.S.
Assistant Dean for Clinical Services

Project Abstract: UNIVERSITY OF SOUTHERN CALIFORNIA
A Computerized Student Evaluation System at the School of Dentistry

The PROJECT GOAL is to allow student and faculty to follow closely the student's qualitative and quantitative progress toward departmental and degree requirements.

IMPLEMENTATION has taken the form of DSIRS: the Dental Student Information Retrieval System. Students are issued 25 preprinted input forms, known collectively as the Computer Input Form Book.

The forms are an integral part of the system in that they serve both as the basis for data input and as a permanent record of the clinical accomplishments of the student. Arranged in groups of five, they consist of the "Start Sheet" (white), the "Completion Sheet" (yellow), "Cashier's Sheet" (green), "Patient's Receipt" (blue) and the "Student's Copy" (pink).

The appropriate forms are completed by student and instructor in the course of the clinical sessions and are subsequently collected. The sheets are verified and data is transferred to punched cards.

Two monthly reports are generated from this data. The Student Progress Report includes a summary of student's standing, work in progress, work completed within the last six weeks (time period arbitrary) and other indicators. A mathematical operation has been devised whereby measures of qualitative and quantitative performance are combined in one overall indicator. The Department Status Report displays the progress of every student in each department.

Programs which generate and support the preceding reports include an edit program, update error programs, summary program, calculation program, student print program and a departmental print program.

The COMPUTER (HARDWARE) SYSTEM is a Honeywell 400, located at the University's Data Processing Center.

VOLUME of data processing includes punching roughly 1500 cards per week. Generation of all six related programs requires a 5½ hour cycle using 14 tapes.

FUTURE PLANS involve the addition of didactic and laboratory courses to the existing computer program, and the automatic analysis of clinic scheduling and assignment of patients to the proper students.

Paul Ehrlich, D.D.S.
Assistant Dean, Clinical Affairs

Project Abstract: UNIVERSITY OF TORONTO
Examiner-Adjusted Clinical Grades Analysis

The PROJECT GOAL is to provide assistance in academic and administrative use of the digital computer.

One aspect of IMPLEMENTATION is the scoring and analysis of Dental Aptitude Test results, as well as other multiple choice tests. Another facet is the establishment of record files for Burlington Orthodontic Research Centre participants.

Perhaps the newest phase of operation involves the current version of the clinical grades analysis program which now features adjustment of examiners' submitted marks prior to analysis and processing.

The clinical grades analysis program is based on department requirements rather than a concept of total patient care and is designed to give a qualitative and quantitative assessment of student progress for each department. Students' grades and class standing are known to be influenced to a greater or lesser degree by rater differences. Thus, the program was developed in response to the volume of clinical assessments, the subjectivity of clinical examiners and the effect of being graded on student attitudes.

To alleviate these problems, the grading scale is adjusted according to a rater's past marking practice, in relation to performance of all examiners in his department, before computation of scores. Once the raw term marks have been determined, they must be rescaled to a mean of 65%, in accordance with faculty policy.

Forms of output include class, individual, and clinical examiner's summaries. The individual summary lists each student as ranked on the basis of examiner-adjusted clinical averages from highest to lowest, while the class summary outlines the examiner-adjusted class average and the standard deviation of this distribution. Department heads have found the clinical examiner's summary very useful.

The Faculty of Dentistry has its own COMPUTER (HARDWARE) SYSTEM, which includes the IBM 1130 system with the recent addition of a Calcomp plotter. An IBM 514 punch is used on the students' mark-sense grading cards. ASSEMBLER and FORTRAN IV are utilized as PROGRAMMING LANGUAGES.

In connection with VOLUME of data processing, it is estimated that 100,000 grades are analyzed annually for two classes of 50 dental hygienist and two classes of 125 dental students. Furthermore, over 200 clinical staff contribute the marks.

A two-sided mark-sense card, a SPECIAL RECORD FORMAT, is used as a record card.

FUTURE PLANS involve examination and modification of existing operations, and the computer-generated scheduling of facilities, timetables, etc. Inventory control is another possible application.

Donald W. Lewis, D.D.S.
Associate Professor,
Dental Public Health and Biometrics

Gordon W. Thompson, D.D.S.
Research Associate, Epidemiology

Project Abstract: WEST VIRGINIA UNIVERSITY Computer Compilation Systems for Clinical Dental Records at the School of Dentistry

The PROJECT GOAL revolves around management of dental records.

IMPLEMENTATION has taken the form of

1. a yearly scheduling program,
2. development of a standard appointment card for all departments,
3. agreement on a uniform numerical and color coding of each department and on a student identity code,
4. a program designed to generate summaries of evaluation of performance in oral diagnosis, and
5. four other general forms of records:
   - a. departmental appointment statistics,
   - b. a table of completed operations,
   - c. a listing of all operations in progress, and
   - d. a list of all students in each class, ranked according to a computation of all of the clinical evaluations.

The COMPUTER (HARDWARE) SYSTEM, located at the Computer Center, had consisted of the IBM 7040 central processing unit, but has been replaced by the IBM 360/75. Eventually, the 360/75 will be moved to a new facility, near the Medical Center. The PROGRAMMING LANGUAGE being used is FORTRAN IV.

Yearly VOLUME of data processing in the Operative Dentistry Department has been estimated at roughly 12,000 clinical data cards, which are converted into about 24,000 punched cards.

The School of Dentistry has no project STAFF of its own, but relies heavily on the staff of the Computer Center and on part-time personnel when available.

SPECIAL PROBLEMS arose in attempting to determine accurate estimates of costs. The Computer Center had not established general guidelines regarding financial responsiblity. Computer time needed for debugging was so uncertain that projects had to be grant-supported. Obtaining the services of a programmer has been another difficulty. Operations are dependent upon quality data, i.e., legible entries.

FUTURE PLANS call for:

1. Determination of choice of equipment and its installation and staffing in a Medical Center facility.
2. The training of departmental secretarial staff for monitoring, storage and transfer of data cards.
3. The extension of use of computer appointment cards to all clinical departments.
4. Modification of existing programs to give a more comprehensive record to each student of his accomplishments.

Long range plans will involve admissions, grading, accounting, patient/student matching, and alumni records.

Robert E. Sausen, D.D.S.
Chairman, Operative Dentistry

APPENDIX

Appendix

List of Participants

ABRAMS, Alan M., M.S.
Statistician, Epidemiology Branch, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118. Tel: (415) 752-2560.

ARIET, Mario, Ph.D.
Coord., Health Center Computer, University of Florida, J. Hillis Miller Health Center, Gainesville 32601. Tel: (904) 392-3608.

Areas: Computer-Assisted Instruction
Status: Planned

BARNETT, James M., M.P.A.
Executive Assistant Director, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118. Tel: (415) 752-2560.

BARR, Charles E., D.D.S.
Assoc. Dean, Assoc. Prof., Periodontics, University of Maryland, School of Dentistry, Baltimore 21201. Tel: (301) 955-7461.

Areas: Student Evaluation (Clinical, Academic), Educational Administration
Computer System: IBM 360/44; FORTRAN IV
Status: 4 years; ongoing

BARTLETT, Richard C., D.M.D.
Assoc. Prof., Coord., Patient Care, University of Kentucky College of Dentistry, Lexington 40506. Tel: (606) 233-5000, ext. 5411.

Areas: Educational Administration
Computer System: IBM 360/65; FORTRAN
Status: 3 years; ongoing

BENNETT, Ian C., D.D.S.
Dean, New Jersey College of Dentistry, Jersey City 07304.
Tel: (201) 877-4633.

Areas: Educational Administration
Status: Planned

BLACKMORE, Nelson L., D.D.S.
Prof. and Chm., Patient Adm. and Records, State University of New York at Buffalo School of Dentistry, Buffalo 14214.
Tel: (716) 831-5381.

Areas: Student Evaluation (Clinical), Educational Administration
Computer System: CDC 6400; FORTRAN IV, COBOL
Status: 4 years; ongoing

BLACKWELL, Robert B.
Communications Specialist, Communication Services, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118.
Tel: (415) 752-2560.

BRESKE, Thomas B.
Systems Analyst, Office of the Director, Dental Health Center, 14th and Lake Street, San Francisco 94118. Tel: (415) 752-2560.

BRODY, Harvey A., D.D.S.
Asst. Prof., Oral Biology and Dentistry, University of California School of Dentistry, San Francisco 94122. Tel: (415) 666-2045.

Areas: Computer-Assisted Instruction
Computer System: IBM 360/50; PILOT
Status: 1 year; ongoing

BROOKRESON, Kendrick, D.D.S.
Prof. and Chm., Oral Diagnosis, Temple University School of Dentistry, Philadelphia 19046. Tel: (215) 229-8500, ext. 352.

Areas: Student Evaluation (Clinical), Educational Administration
Computer System: NCR
Status: 2 years; ongoing

CAMPBELL, Edward M., D.D.S.
Dir., Dental Manpower Development Center, Div. of Dental Health, Louisville 40202. Tel: (502) 582-5228.

CARTER, Donald F.
Design Engineer, Professional Education Branch, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118.
Tel: (415) 752-2560.

CHENG, Samuel, D.D.S.
Asst. Clinic Dir., University of California School of Dentistry, Los Angeles 90024. Tel: (213) 825-5896.

Areas: Admissions, Student Evaluation (Clinical), Educational Administration
Computer Systems: IBM 36/50, IBM 360/91; FORTRAN, COBOL
Status: 3 years; ongoing

CLARK, John P. H., D.D.S.
Prof., Pharmacology and Operative Dentistry, Chm., Operative

Dentistry, Case Western Reserve University School of Dentistry, Cleveland 44106. Tel: (216) 368-3260.

Areas: Student Evaluation (Clinical)
Computer System: G.E. 225
Status: 2 years; ongoing

COLLINS, Edwin M., D.D.S.
Asst. Dean, Prof., Diagnosis and Treatment Planning, Loma Linda University School of Dentistry, Loma Linda 92354.
Tel: (714) 796-7414.

Areas: Student Evaluation (Clinical)
Computer System: FORTRAN
Status: 3 years; ongoing

COURY, Victor M., Ed.D.
Prof. and Chm., Education and Counseling, University of Tennessee College of Dentistry, Memphis 38103.
Tel: (901) 527-6641, ext. 272.

Areas: Student Evaluation (Academic), Computer-Assisted Instruction
Status: Planned

CRANDELL, Clifton E., D.D.S.
Dir., Dental Data Center, Assoc. Prof., Oral Diagnosis, University of North Carolina School of Dentistry, Chapel Hill 27514.
Tel: (919) 966-1161.

Areas: Educational Administration
Computer System: IBM 360/75; PL/1
Status: 4 years; ongoing

DARBY, Dean W., D.D.S., Ph.D.
Dental Director, Professional Education Branch, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118.
Tel: (415) 752-2560.

'DUNBAR, Charles R., M.S.
Research Asst., Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford 94305.
Tel: (415) 321-2300, ext. 2967.

Areas: Computer-Assisted Instruction
Computer Systems: IBM 1500, IBM 360/50, PDP-10; COURSEWRITER, PILOT
Status: 3 years; ongoing

DUROCHER, Roy T., D.D.S.
Assoc. Dean and Dir. of Clinics, University of Pittsburgh School of Dental Medicine, Pittsburgh 15213.
Tel: (412) 683-8400, ext. 608.

Areas: Educational Administration, Computer-Assisted Instruction
Computer Systems: IBM 7090, IBM 360/50, IBM 360/20, PDP-4; MAD, PL/1, FORTRAN IV, ALGOL, COBOL
Status: 10 years; ongoing

EHRLICH, Paul, D.D.S.
Asst. Dean, Clinical Affairs, Assoc. Prof., Fixed Prosthodontics, University of Southern California School of Dentistry, Los Angeles 90007. Tel: (213) 746-2821.

Areas: Student Evaluation (Clinical)
Computer System: Honeywell 400; COBOL
Status: 3 years; ongoing

FRENZEL, Winston W., D.D.S.
Regional Dental Consultant, Region IX, Div. of Dental Health, Federal Office Building, 50 Fulton Street, San Francisco 94102.
Tel: (415) 556-4410.

FRIEND, Jamesine, B.A.
Research Assoc., Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford 94305.
Tel: (415) 321-2300, ext. 2954.

Areas: Computer-Assisted Instruction
Computer Systems: IBM 1500, PDP-1, PDP-10; ASSEMBLY LANGUAGE, COURSEWRITER
Status: 5 years; ongoing

GASTON, Gerald, D.D.S.
Project Supervisor, Computer-Assisted Instruction Study, Continuing Education for Health Professions, Ohio State Regional Medical Program, Columbus 43210. Tel: (614) 293-8127.

Areas: Computer-Assisted Instruction
Computer System: IBM 360/40; COURSEWRITER III
Status: 2 years; ongoing

GINLEY, Thomas J., Ph.D.
Assoc. Sec., Council on Dental Education, American Dental Association, Chicago 60611. Tel: (312) 944-6730.

Areas: Admissions, Student Evaluation (Academic), Aptitude Testing Research

Computer System: Honeywell 200; EASY CODER, COBOL
Status: 4 years; ongoing

GLASS, Robert L., D.M.D., Dr. P.H.
Assoc. Prof., Dentistry, Forsyth Dental Center, Harvard Dental School, Boston 02115. Tel: (617) 734-3300, ext. 2267, or (617) 262-5200.

Areas: Epidemiology, Clinical Research
Computer System: IBM 360/50; FORTRAN IV
Status: 10 years; ongoing

GRUBB, Ralph E., M.S.
Research Psychologist, Education Research, International Business Machines Corporation, Monterey and Cottle Roads, San Jose, California 95114. Tel: (408) 227-7100, ext. 6232.

HALSTEAD, Charles L., D.D.S.
Assoc. Prof., Pathology, Chm., Oral Medicine, Emory University School of Dentistry, Atlanta 30322. Tel: (404) 377-2411, ext. 6856.

Areas: Admissions, Student Evaluation (Clinical, Academic), Educational Administration
Computer System: RCA Spectra 70/55; FORTRAN, COBOL
Status: 1 year; ongoing

HANSEN, Robert G., D.D.S.
Assoc. Dean, University of Oklahoma School of Dentistry, Oklahoma City 73104. Tel: (313) 763-2105.

Areas: Educational Administration
Status: Planned; previously associated with University of Michigan project

JACOBS, Richard M., D.D.S., Ph.D.
Assoc. Dean, University of Iowa College of Dentistry, Iowa City 52240. Tel: (319) 353-5723.

Areas: Educational Administration
Computer System: IBM 360/65; FORTRAN IV
Status: 2 years; ongoing

JAMISON, Homer C., D.D.S., Dr. P.H.
Prof., Preventive and Community Dentistry, University of Missouri–Kansas City School of Dentistry, Kansas City 64106. Tel: (816) 842-0645, ext. 40.

Areas: Student Evaluation (Clinical)

Computer System: IBM 360/30; FORTRAN IV, RPG
Status: 1 year; ongoing

JOLLEY, William H., D.D.S.
Acting Dean, University of Tennessee College of Dentistry, Memphis 38103. Tel: (901) 527-6641, ext. 231.

Areas: Student Evaluation (Academic), Computer-Assisted Instruction
Status: Planned

KAMP, Martin, M.D.
Chief, Instructional Division, Office of Information Systems, University of California Medical Center, San Francisco 94122.
Tel: (415) 666-2860.

Areas: Computer-Assisted Instruction
Computer System: IBM 360/50; PILOT
Status: 4 years; ongoing

KILLIP, Devore E., D.D.S.
Dir., Division of Education Resources, University of Iowa College of Dentistry, Iowa City 52240. Tel: (319) 353-4380.

Areas: Computer-Assisted Instruction
Computer Systems: IBM 1500, IBM 360/65; COURSEWRITER III
Status: 3 years; ongoing

KLAPPER, Clarence E., Ph.D.
Prof., Anatomy, Chm., Admissions Committee, University of Alabama School of Dentistry, Birmingham 35233.
Tel: (205) 934-4566.

Areas: Admissions
Computer System: IBM 7040; FORTRAN IV
Status: 2 years; ongoing

KREIT, Leonard H., Ph.D.
Research Psychologist, Professional Education Branch, Dental Health Center, 14th Avenue and Lake Street, San Francisco 94118.
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KROEGER, Donald C., Ph.D.
Prof. and Chm., Pharmacology, University of Texas Dental Branch, Houston 77025. Tel: (713) 529-4871, ext. 341.

Areas: Admissions, Student Evaluation (Clinical, Academic), Educational Administration
Computer Systems: IBM 7094, IBM 360/50; FORTRAN IV, PL/1
Status: 3 years; ongoing

KUNIHIRA, Shirou, Ph.D.
Assoc. Prof., Psychology, Loma Linda University School of Dentistry, Loma Linda 92354. Tel: (714) 796-7414, ext. 659.

Areas: Student Evaluation (Academic), Computer-Assisted Instruction
Computer System: FORTRAN
Status: 3 years; ongoing

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Areas: Student Evaluation (Clinical), Clinic Operations
Computer System: IBM 360/30
Status: 1 year; ongoing

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Areas: Student Evaluation (Clinical)
Computer System: IBM 1130; FORTRAN IV
Status: 10 years; ongoing

LEWIS, Lloyd A., Ph.D.
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Areas: Computer-Assisted Instruction
Computer Systems: IBM 1500, IBM 360/65
Status: 3 years; ongoing

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Areas: Educational Administration

Status: Planned; previously associated with University of Kentucky project

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Areas: Educational Research
Status: Planned; previously associated with University of Pittsburgh project

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Areas: Admissions, Simulation
Status: Planned

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Areas: Educational Administration
Computer System: IBM 360/50; FORTRAN
Status: 3 years; ongoing

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Areas: Educational Administration
Status: Planned

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Areas: Computer-Assisted Instruction
Computer System: IBM 360/50; PILOT
Status: 1 year; ongoing

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Areas: Student Evaluation (Clinical)
Computer Systems: IBM 7040, IBM 360/75; FORTRAN IV
Status: 3 years; ongoing

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Areas: Computer-Assisted Instruction
Computer System: IBM 1130
Status: 3 years; ongoing

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Areas: Simulation, Operations Research, Automated X-Ray Analysis
Computer System: IBM 7094
Status: 2 years; ongoing

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Areas: Computer-Assisted Instruction
Computer System: IBM 1130; FORTRAN
Status: 2 years; ongoing

SMITH, Roulette W., M.S.
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Areas: Educational Administration, Computer-Assisted Instruction, Psychology
Computer Systems: PDP-1, PDP-8, PDP-10; FAIL, MACRO, GOGOL, LISP, PASS, COURSEWRITER
Status: 6 years; ongoing

STARKWEATHER, John A., Ph.D.
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Areas: Educational Administration
Computer Systems: IBM 1130, IBM 360/67; FORTRAN IV
Status: 3 years; ongoing

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struction Study, Ohio State Regional Medical Program, Columbus 43210. Tel: (614) 293-8127.

Areas: Computer-Assisted Instruction
Computer System: IBM 360/40; COURSEWRITER III, VERSION 2
Status: 2 years; ongoing

TODD, Jr., Aaron G., M.S.
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Areas: Student Evaluation (Clinical, Academic), Individual Instruction
Status: Planned

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Areas: Educational Administration
Status: Planned

VITO, Anthony, A., D.D.S.
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Areas: Student Evaluation (Clinical), Educational Administration
Computer System: IBM 360/75; COBOL
Status: 2 years; ongoing

WEBER, John C., D.D.S.
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Areas: Computer-Assisted Instruction
Computer System: IBM 1500; COURSEWRITER II
Status: 2 years; ongoing

WEISENFELDER, Harry, B.A.
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Assoc. Prof. and Head, Bio-Mathematics, University of Texas M.D. Anderson Hospital and University of Texas Dental Branch, Houston 77025. Tel: (713) 526-5411, ext. 451.

Areas: Simulation, Biostatistics
Computer Systems: SDS Sigma 5, EAI 680, IBM 7094; FORTRAN, SYMBOL
Status: Ongoing

Conference Staff

Dale W. Podshadley, D.D.S.	Conference Chairman
Luigi F. Lucaccini, Ph.D.	Program Chairman
Martin L. MacIntyre, D.D.S.	Local Arrangements Chairman

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Student Evaluation in Clinical Coursework

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